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NOTICE.

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EARWIGS.—II.

By E. A. Butler.

(*Continued from page* 183.)

THE partiality of Earwigs for flowers, and particularly for dahlias, has led to the adoption of various devices in gardens to get rid of them, advantage being taken of their fondness for dark corners. Mouffet, an old writer to whom we have referred before, speaks of "ox-hoofs, hogs'-hoofs, or old cast things" as being set up in his time on sticks as traps by the country women, to whom Earwigs, or erriwiggles, as they call them, are exceedingly hateful, as he says, "because of the clove gilliflowers that they eat and spoyl." Crabs' and lobsters' claws have been used with effect in a similar manner. Into the recesses of these the Earwigs delight to penetrate in the daytime, just as they have learnt to do into the spurs of the tropæolum flowers (Fig. 4) since

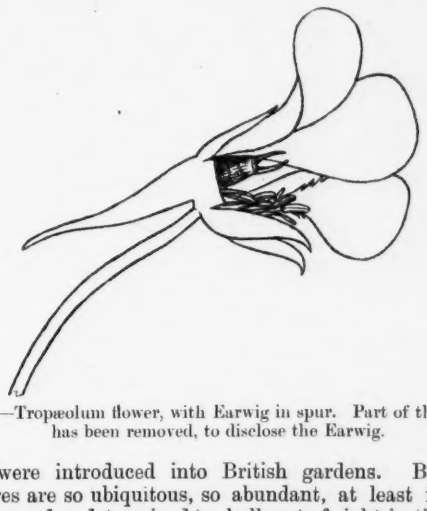


Fig. 4.—Tropæolum flower, with Earwig in spur. Part of the flower has been removed, to disclose the Earwig.

these were introduced into British gardens. But the creatures are so ubiquitous, so abundant, at least in this country, and so determined to skulk out of sight in the daytime, squeezing themselves into most out-of-the-way places, under stones, tiles, bark, leaves, or garden rubbish of any kind, wherever there are but a few cubic millimetres of breathing space, that it is next to impossible to devise means which shall be very effectual in reducing their numbers. Not only do they damage flowers, but like wasps, they are destructive to ripe fruit as well; De Geer fed some of those he kept with chopped apples, which they eagerly devoured. Windfalls from the fruit trees in orchards are soon found out and excavated by Earwigs, which in the daytime curl themselves up in the hollows they have made in the fruit, sticking close to their booty, ready to fall to again as soon as the promptings of hunger and the return of darkness combine to render a banquet desirable and safe. Though, as a rule, vegetarian in diet, yet they have no objection to eating animal food if opportunity serves, and as we have already seen, may even, when hard pressed, resort to cannibalism; but experiments seem to indicate that they will be prepared to suffer great extremities before falling back on such a practice. They may be kept for a long time in numbers together, without showing any disposition to attack one another, even if the supply of food be scanty. They are not often found indoors, but if accidentally introduced, may sometimes do irretrievable damage. The entomologist especially has to be on his guard against them; if they do manage to gain access to his setting boards, they have no hesitation in trying their jaws upon the insects that may be stretched on them. The antennæ of dried insects, particularly of certain special kinds, seem to be peculiarly delicate morsels. The little booklouse, when attacking insects mounted on card, usually makes for the antennæ first; and the Earwig seems to have a similar taste. One collector records that a single Earwig passed along his boards, and in two days removed the antennæ from thirty-six moths all belonging to one species, while exampies of other species were left untouched. The entomologist who hunts for moths at night by smearing the syrupy liquid, technically called "sugar," on the trunks of trees as a bait, often finds, on revisiting his trap, that crowds of Earwigs have found out the store, and are revelling in the tempting sweets.

Hitherto we have spoken only of the Common Earwig

(*Forficula auricularia*). A word or two may now be said about the remaining British members of the family. The only other that is at all common is that called the Little Earwig (*Labia minor*), (Fig. 5), a much smaller insect, easily distinguished by that feature alone. It is a flat little thing, hardly more than a quarter of an inch long, forceps and all, of a yellowish-brown colour, with darker head and antennæ, and pale straw-coloured sprawling legs. For some reason not very easy to discover, it manages to do with only ten or twelve joints to its antennæ, instead of the fifteen of the larger species, and the last two of these are, equally inexplicably, of a pale yellow colour, the rest being deep brown. The forceps of the male differ greatly from those of the larger species, and are much less elegant. At the point where they join the body they are widely separated from one another, instead of being nearly contiguous; they are only slightly curved, and have no teeth on the inner edge. The forceps of the female, on the other hand, are very similar to those possessed by the same sex in *Forficula auricularia*. This little insect is not nearly so retiring in its habits as its larger relative. Its wings are rather larger in proportion to its body, and it is much more ready to use them. It may be found flying, even in the daytime, about gardens and dunghills, and so little fears the neighbourhood of man that it is sometimes met with in busy streets, flying, or running about on the pavement at the imminent risk of its life from the feet of passers-by. About midsummer is the best time to find the Little Earwig; it is not nearly so plentiful as the larger species, though fairly common, and it probably does but little damage.

Fig. 5.—Little Earwig (*Labia minor*), male. Magnified four diameters.

In great contrast to this little creature is the Giant Earwig (*Labidura riparia*), which is as rare as either of the other two is common. It is a fine large insect, over an inch long, of a reddish-yellow colour. Its size alone is sufficient to distinguish it from almost all our other species. It was first recorded as a British insect in 1808, when the Rev. W. Bingley found it in some numbers near Christchurch, Hants. This seems to have been its head-quarters, but it spread east and west from this locality, and the places at which it has since been captured range along the south coast from Dorsetshire to Kent. The last recorded specimen was taken five years ago on the coast of Dorsetshire. As the insect seems to have been plentiful when first discovered, it is possible that it may still be existing in greater numbers than the records of its capture would lead us to infer; and those who live in the region of its former metropolis should keep a sharp look-out, especially near high-water mark and towards evening, when they may perhaps gain an introduction to stray individuals of this fine species, as they come out for their nightly foraging. The forceps of the male have a large tooth on their inner side like those of the Common Earwig, but it is situated nearer the tip.

Besides this rare southerner, there is also a still rarer northerner, *Anisolabis maritima* by name, which was found at South Shields in 1856, by that indefatigable entomologist, Mr. T. J. Bold. As it was discovered so near a port and had not been met with elsewhere, Mr. Bold thought that it had been introduced by shipping; but as he found a young one in the autumn, it would seem that the species had begun to make itself at home by establishing a nursery, and had settled down, at least for a time. It is rather larger than the Common Earwig and differs also in colour, being dark blackish-brown above and yellowish beneath. But its most striking point of difference is the entire absence of wing-covers and wings, a peculiarity which makes it look like an overgrown larva. The forceps of the male are remarkable in being unequally curved, whereby they acquire an aspect of deformity; the right branch is more curved than the left. Whether this insect has permanently established itself on British soil and is still to be met with in the neighbourhood of its first appearance, or whether it has found the climate uncongenial, or the accommodation unsuitable, and has therefore yielded to the force of circumstances and become extinct, so far as our own country is concerned, is not definitely known. Here then is an opportunity for our north country friends to distinguish themselves by the re-discovery of the wingless Earwig of South Shields.

The next species is *Forficula pubescens*, a yellowish-brown insect, smaller than its close ally, the Common Earwig. Scarcely anything is yet known of the distribution of this insect in Britain, and as there are very few people who take the trouble to record the doings of such despised things as Earwigs, it may be long before more definite information is obtained. It is a south European species, but it has been recorded from some places on the Dorsetshire coast, and might very likely turn up in other localities as well, if only properly looked for. It is in an intermediate condition between the last-mentioned insect and the Common Earwig, having wing-covers indeed, but scarcely anything worth calling wings for them to cover; and thus we see that though the number of British Earwigs is so small, they are, nevertheless, an exceedingly interesting collection, since they represent the chief variations of form we might expect to find in a single family of insects.

Our sixth and last species is another pale and rare one called *Chelidura albipennis*. Here again we have a wingless Earwig; its wing-covers are perfectly formed, but they protect no wings, and consequently the insect cannot fly. It is very variable in size, sometimes only slightly longer than the Little Earwig, at others much bigger; its body and forceps are both hairy. It is widely distributed on the Continent, and in England has been caught by Professor Westwood at Ashford. As these various species of wingless Earwigs have in all cases perfectly developed forceps, it seems pretty plain that whatever aid these instruments may sometimes render in the manipulation of the wings, such a function can neither be the only, nor indeed the chief use of them, else they would in the apterous forms have followed the wings into a state of abortion. Nor can we imagine a sensory use for them, such as was suggested for the two pointed styles of the house cricket, and possibly for the two spindle-shaped organs similarly situated in the cockroach: the Earwig's forceps are too hard for anything of this kind, and we are thrown back, therefore, on the hypothesis that their chief function is that of an offensive and defensive armature.

Notwithstanding their retiring habits, Earwigs do not escape from the attacks of parasites. Westwood states that there is a kind of ichneumon fly which attacks the Common Earwig, depositing eggs in its body, the contents of which are devoured by the larvæ hatched from them; and I have myself found a large fleshy maggot, apparently that of a flesh-eating Dipterous fly, inside the body of a full-grown Earwig. Internal insect parasites such as these, whether Hymenopterous, like the ichneumon fly, or Dipterous, like the maggot above referred to, when attacking insects which pass through a complete metamorphosis, usually become mature while their host is in the

chrysalis condition, and thus the latter does not itself reach maturity, but perishes while still a chrysalis, through the development and exit of the parasite. Here the very fact of the host's being in a quiescent condition, and taking no food, is the means of sounding its own death knell, the parasite absorbing its vital tissues while it has no power of repair; the parasite is complete master of the situation, and, in consequence, it is the rarest thing imaginable for the host to struggle on to maturity. But with such an insect as the Earwig the case is different. Here we have an insect which has no quiescent pupa stage, but continues to take food throughout life, thereby to some extent perpetually neutralizing the effect of the parasite's attacks; and it is hardly surprising, therefore, that in such a case the maturation of the parasite should be delayed till much later in the life of the host, and that the latter should thus be able to reach maturity in safety. As a factor in the perpetuation of its race, however, it would probably be just as devoid of influence as if it had died in pupahood, as the parasite would probably subsist at the expense of its reproductive organs, and thus render it barren. The exit of the parasite, under such circumstances, would be an interesting event to witness, and one would be glad to know the precise point at which it escapes, as well as the means by which it bursts through, for the skin of the perfect Earwig is much harder and tougher than it is during the larval and pupal stages, and the parasite is therefore much more effectually imprisoned. Besides these insect parasites, a *Filaria*, or thread-worm, has been discovered infesting the Common Earwig, as well as a *Greyarina*, a creature of much simpler organization even than the thread-worm.

The systematic position of Earwigs has been a matter of considerable controversy; they constitute a very compact family—the *Forficulidæ*—and were placed by Linné in the order Coleoptera, or beetles. In some respects they certainly do exhibit a tolerably close resemblance to one particular group of this order, viz. the rove-beetles, a set of carrion and dung-feeders which are technically called Brachelytra. These are beetles of narrow elongate body, with very short wing-covers, so that the greater part of the abdomen is exposed, instead of being, as is generally the case, concealed beneath the overarching elytra, or wing-covers. It was this small size of the flying apparatus which suggested the name of the group, Brachelytra being Greek for "short elytra." Some of the larger species of this group (Fig. 6) are about the size of Earwigs, and in consequence of their elongate form and short elytra are very generally mistaken for them, the resemblance being sometimes heightened by the presence of short, pointed, projecting organs at the end of the body in the position of the true Earwig's forceps. But the resemblance is after all only a superficial one. No true projecting *forceps* are ever developed in the rove-beetles; their wings are differently veined and differently folded from those of Earwigs, and lastly, and most important of all, the life-histories of the two groups are utterly unlike, for the rove-beetles pass into a quiescent chrysalis stage before becoming perfect insects, which is never the case with Earwigs. By later systematists the Earwigs were removed from the Coleoptera and put into the Orthoptera, amongst the cockroaches, crickets, grasshoppers, and locusts, forming, however, a distinct section of the order. In the nature of their mouth organs and the style of their metamorphosis they do indeed resemble these insects, yet they are so peculiar, in the matter of the wings, that their location with the Orthoptera did not satisfy all naturalists; consequently Kirby in 1823 removed them and made them into a separate order by themselves, under the name Dermaptera, an unfortunate piece of nomenclature, since this term had previously been adopted as the name of the whole order which is now called Orthoptera. Westwood therefore proposed to replace the name Dermaptera by Euplexoptera (well-folded wings), in allusion to the complicated system of wing-folding which distinguishes Earwigs; but the pendulum has again swung round in the opposite direction, and they are now again grouped, at least by professed entomologists, in the order Orthoptera.

Fig. 6.—*Philonthus æneus*, a Rove-Beetle, sometimes mistaken for an Earwig. Magnified three diameters.

We may conclude with a brief reference to the peculiarities of the popular names of these well-known pests. It is remarkable that in almost all the languages of Europe they are known by names which have some connection with the word "ear." It is always the ear "worm," "borer," "piercer," "twister," or something of that sort, names which obviously reflect the vulgar and wide-spread superstition that the Earwig creeps into the human ear and causes death by effecting thence an entrance into the brain. It is curious that so manifestly absurd an idea should ever have gained such wide credence—so wide indeed as to have been incorporated into the traditional lore of all the most civilized nations of the world—and still more so that it should even yet show strong signs of vitality. Such a notion of course explains the popular prejudice against the Earwig, which indeed is not an insect that has ever succeeded in inspiring either admiration or respect; on the other hand, superstitious fear, hatred, or contempt have generally been the feelings with which it has been regarded, and even its name was once used as a scornful epithet, a synonym for an "inquisitive informer"—no doubt in allusion to its habit of poking its head into corners.

THE MUSHROOM.

By J. Pentland Smith, M.A., B.Sc., &c.
(*Lecturer on Botany, The Horticultural College, Swanley.*)

DURING the months of September and October, especially if the air be moist and warm, inviting-looking patches of white-capped Mushrooms spring up in the green grass fields. Some are small like round white buttons; others are large and have the appearance of a plate supported on a stalk. These larger ones are much darker in colour than their diminutive neighbours. They grow with great rapidity. I have gathered Mushrooms one morning, leaving the ground destitute of a vestige of them, and two mornings afterwards an abundant crop has presented itself on the same spot.

The common Mushroom is a member of a very large genus—the genus *Agaricus*. It consists of some hundreds of species, and has been broken up into a number of sub-genera, and to one of these, *Psalliota*, the common Mushroom belongs. Its botanical name is *Agaricus* (*Psalliota*) *campestris*.

The stalk, technically called the *stipe*, which is so evident in older specimens, is cylindrical in shape, and in colour generally white. The disc which it supports is termed the *pileus*. Its colour is variable, whitish and flaky on its upper surface, as a rule, but at times brown and scaly. Alteration of situation affects it in this way, as is the case with many other plants.

On the under surface of the cap are a number of gills of a brown colour, disposed in a radial fashion. They are not all of the same size, some running from the stalk to the periphery, while others stop at intermediate places on the way, but they are all disposed so that the interspaces between the adjacent gills are kept of the same breadth. Half-way up the stalk of the older specimens, which we are supposed to be examining, there is a collar formed of a flaky material which has the appearance of having been torn from some other body in the course of its growth. It is called the *velum* or veil. A glance at a series of specimens, ranging in age from the button stage upwards, reveals the origin of the veil. In the youngest, the gills are not visible, the cap is nearly spherical and its margin lies near the upper portion of the stalk (Fig. I., 3). The existence of a cavity formed by the cap and the stalk is obscured by a membrane joining the periphery of the cap and the stalk. An older form shows that a tearing of this tissue is taking place consequent on the expansion of the cap, and the line of rupture is near the circumference of the cap. As the cap increases, the membrane is completely separated from it and is left as a frayed ring on the upper part of the stalk.

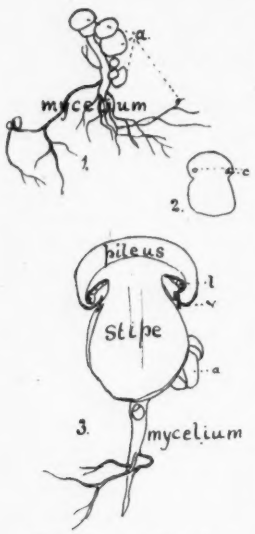


Fig. I. 1. Mycelium (spawn) of Mushroom carefully washed. Young fructifications (Mushroom plants), *a*, are seen arising on it. 2. Young Mushroom cut vertically through the centre, showing the cavities, *c*, into which the gills will afterwards grow. 3. Longitudinal radial section of young Mushroom at a later stage than 2; *l*, gills; *v*, velum or veil; *a*, younger Mushrooms.

The gills in the younger specimens are often of a delicate pink hue, while in others they are whitish. In fact, we are dealing with a very variable species, which is common in rich pastures, according to Berkeley, in most parts of the world.

The base of the stalk is connected with a number of white threads. If we carefully remove the earthy and other particles from these we shall find that other stalks are connected to them, so that we have a large number of Mushrooms all united together by these strands. Made up in dry patches of manure, the threads or strands are sold in shops under the familiar name of Mushroom spawn. They ramify through the soil wherever these forms grow. In all probability, then, there is some vital connection between the Mushroom spawn and the Mushroom plant.

If the cap of a Mushroom, just arrived at maturity, be placed in its natural position on a sheet of paper and allowed to remain there for some time in a still atmosphere, it will be found, on removing it, to have left an impression of its gill system on the paper, by the deposition of minute dust-like particles, which naturally suggest to one's mind their connection with the gills themselves. They are so minute that a hand lens is useless for their examination, so we select a portion of the cap and place it in a slit in a piece of pith, and with a razor wetted in dilute alcohol we cut an extremely thin tangential vertical section. Under a lens the section appears as represented in Fig. II., 1.; under a low power of the microscope, a single lamella has the appearance of Fig. II., 2. In the centre is a lax tissue composed of elongated cells, and called the *trama*. It is bordered on both sides by smaller cells which form the *sub-hymenial layer*. Surrounding this layer is a belt of larger cells, the *hymenial layer*. On some of these may be noticed two minute stalks bearing, each one, a small oval body. This will be better observed on reference to Fig. II., 3, which is a small portion of the lamella very much magnified. The oval bodies are called *spores*. They are of a brownish-purple hue. The stalks on which they arise are termed *sterigmata*, and the cell which bears sterigmata is called a *basidium*. Between the basidia are cells which do not bear spores, but appear to act as padding. They are known as *paraphyses*.

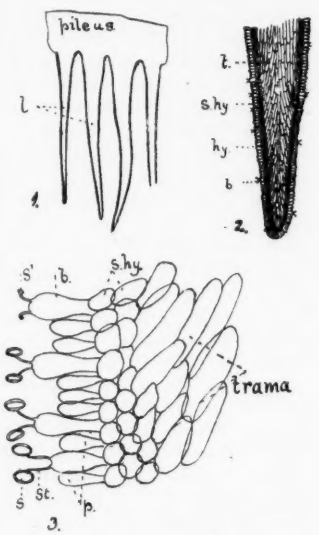


Fig. II. 1. Longitudinal section of cap, showing gills (enlarged). 2. Magnified representation of a gill of 1; *t*, trama; *s. hy*, sub-hymenial layer; *hy*, hymenium; *b*, basidium. 3. Very much magnified view of a small portion of above; *p*, paraphyses; *b*, basidium; *s*, spore; *s'*, developing spore; *st*, sterigma; *s. hy*, sub-hymenial layer.

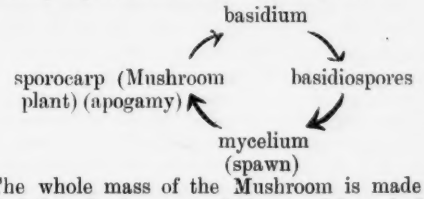
The spores of *Agaricus campestris* and of the *Hymenomycetes* (the division of Fungi to which it belongs) generally are comparable, according to some, to the gonidia of the potato-disease fungus, that is, they have been formed asexually. According to others they are true spores, but as male and female organs have never been found in this plant, apogamy (or suppression of the union of male and female elements) is supposed to have taken place. For the sake of convenience we call them spores, and the Mushroom plant on which they arise, the *sporophore*.

From the spores the Mushroom plant arises. It is curious, however, that the germination of these, in the particular species with which we are now dealing, has never been observed, although it has been seen in allied forms. In these cases there were many failures before good results were obtained, these being due to conditions of temperature and moisture, &c., so that far from destroying our hopes in this case, we may look soon for an account of observations on the germination of the spores of *Agaricus campestris*.

Nevertheless, at the present time curious speculations have arisen anent these spores, and the botanist's inability to germinate the spores has given an air of truth to them rather than otherwise. Mr. Straton, writing in *Nature*, of 16th November, 1890, states: "The common Mushroom (*Psalliota campestris*) is particularly agreeable to sheep and oxen, and is abundant in autumn in rich pastures. Although there is still much in our knowledge of its life-history that is incomplete, yet it is evidently composed of two main periods: first, a parasitic period passed in the body of an animal host; and secondly, a saprophytic period passed on some suitable organic soil. Let us sow the

spores of a ripe Mushroom as carefully as we may, none of them will grow; the first stage of the Mushroom's existence must be passed in the body of an animal host, and as horses, sheep, and oxen are all readily attracted by its taste and mealy smell, it has never any difficulty in finding a host to take it in." Mr. Straton here takes it for granted that the spores must pass through the body of an animal such as the horse before germination will take place, and he consequently adduces the pleasant smell and taste of the Mushroom as attractive characters of value to the plant. But has a short residence within an animal host been proved to be a necessary probation to germination? I think not. It may or may not be the case, however. The question is an interesting one, and my remarks may, perhaps, elicit further information on this point. Mr. M. C. Cooke, in an article on the "Attractive Characters of Fungi,"* does not evidently give unqualified assent to the opinion expressed by the writer just quoted. He states: "Whether horses, oxen and sheep really *eat* the common Mushroom we venture to call in question, but they *do* eat the grass upon which the fungus spores have fallen." We have observed horses, cattle and sheep eating the grass all around where Mushrooms have been growing, and seen them pass on, leaving the Mushrooms for us to gather on our own account. This does not show much animal predilection for fungus food, and hardly bears out the paragraph that "horses, sheep and oxen are readily attracted by the taste and mealy smell." Without venturing to throw doubt upon the old faith that the spores of the Mushroom are destined to pass through the entrails of a horse, or that a horse or cow may sometimes even eat a Mushroom if it comes in its way, still we have great hesitation in accepting as an article of belief that they seek them out and devour them bodily, for the sake of the preservation of the species." Another writer maintains that insects, such as flies and beetles, whose larvæ are often met with in decomposing Mushrooms, are the active agents as much as horses and oxen in developing the spores. He believes that a sustained temperature may be necessary for their development, and this they find in the bodies of these animals. Does this not seem nearer the mark, than the statement that during a period of its existence the Mushroom is a parasite —that is, it feeds on the tissues or juices of a living host?

The product of the germinated spore consists of a number of fine threads, or hyphæ, which unite to form the spawn, or mycelium. The mycelial strands may sometimes attain the thickness of thin whipcord. They are produced by a weaving together of the hyphal filaments. Here and there small knobs appear on them, which develop gradually into the Mushroom. The tissue of these is at first continuous, but soon disintegration takes place, resulting in the formation of an annular cavity dividing the circumferential portion of the cap from the stalk. (Fig. I., 2, *c*.) Into this cavity down-growths of the cap make their appearance and form the gills. The tissue of the gills is a further development of that of the cap. The ends of the filaments which border the gills are, as may be seen on reference to Fig. II., at right angles to that of the trama. In the trama the filaments are not closely woven together; while in the sub-hymenial layer they are so closely wefted that it appears as made up of small closely compacted cells. Outside the sub-hymenial layer the extremities of the filaments form the basidia and paraphyses. From the ends of the basidia the stalks, or sterigmata, arise. A swelling sooner or later appears at the apex of each sterigma, and this enlarges into a spore, which, because it is produced on a basidium,† is called a basidiospore. The spores contain the greater part of the protoplasm of the basidia. They soon acquire a thick coat, and their connection with their parent becomes less and less until at last they drop off as the purplish-brown bodies of which we previously spoke. The life-history diagrammatically represented would be as follows:—



The whole mass of the Mushroom is made up of the wefted threads of enormously long and branched filaments, which have been produced presumably from a single spore. We have no evidence, however, against the assumption that the mycelium on which a Mushroom arises has arisen from more than one spore. The Mushroom has all its parts developed some time before it is seen above ground. Its unexpected appearance there is doubtless consequent on an increase in the size of its cells, and not on the formation of new cells. "In *Agaricus vulgaris*," De Bary says, "I succeeded in determining, by measurement of the cells and counting their number on the transverse section, that the increase in length and breadth of the stipe, which becomes, on an average, 50—60 mm. long, from the time when its length was about 3 mm., and its cells could be exactly measured, must be almost exclusively due to an extension of the cells."‡

During the primary stages of its growth, the cells on the upper surface of the cap grow more rapidly than those on the lower. The secondary period is marked by a more rapid growth in the opposite direction, so that the margin of the cap is brought further and further from the stalk.

From what has been already indicated we can see that the tissue of the Mushroom is not a true tissue, but such as appertains to the lowest forms of plants—the Fungi. The Mushroom, then, is a fungus. Its mode of life is typical of that seen in the majority of the members of that group. In its cells there is no green colouring matter (chlorophyll), and in consequence it is unable to make use of the carbon dioxide of the air as its source of carbon. It relies upon other sources for it, finding it in the decaying vegetable matter of the manure of sheep, horses, oxen, &c. It assimilates the already elaborated carbonaceous materials by the action of a ferment secreted at the tips of the fibrils of its mycelium, and also takes up mineral matters from the soil.

The mycelium or spawn exists apparently for years below ground, that is to say, it is perennial, while the fructifications—the conspicuous Mushroom plants — are transitory structures; but as no one has observed the germination of a spore, we are unable to say what time must elapse between that act and the production of a Mushroom plant. It is the spawn which absorbs the nutrient material. Its effect upon its surroundings is sometimes seen in the production of "fairy rings," although these are not so commonly formed by this species as by some of its allies. The miraculous origin of these rings has now been exploded; poets must be content with a less imaginative, although at the same time more

* *Nature*, 20th November, 1890.

† A cell, from the end of which a spore is produced in the manner indicated, is called a basidium.

‡ De Bary, "Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria," page 55.

satisfactory, interpretation of their appearance. Many fungi of the Mushroom tribe show a tendency to spread in all directions from the spot where their mycelium has first obtained its hold on the soil. They exhaust the soil, so that the grass does not grow well there, but as they spread further out, the place on which they formerly stood produces a luxuriant crop of grass, on account of the extra supply of nutritious matter formed by the decay of their bodies. Thus poor and then good grass follow one another on the same zone of soil.

Agaricus campestris is of use to men, but a few of its allies are the dread of the forester, and others are deadly poisonous. It may be remarked in passing, however, that the majority of the cap-fungi are not poisonous, and that more use should be made of the large number of edible fungi which we have in this country. Of these the Mushroom is the only one under cultivation. Mushroom beds are well known to gardeners, and it is not an uncommon thing now-a-days to find a range of darkened houses specially devoted to their culture. A curious use has been made of an old railway tunnel—the Scotland Street Tunnel—in Edinburgh. The visitor to this excavation will find that, in place of railway sleepers and lines, the ground is occupied by carefully prepared beds, on which arise luxuriant crops of the favourite Agaric. Although in great request in this country, Berkeley, writing upwards of thirty years ago, states that it is "most carefully excluded from the Italian markets," owing probably to occasional poisoning symptoms that have shown themselves after its consumption. So far as we know, the Mushroom has never been known to have exhibited poisonous properties in this country. If the Italians are correct, we have a good example of the influence on a plant of its surroundings.

CROCODILES AND ALLIGATORS.

By R. Lydekker, B.A.(Cantab.)

In spite of the circumstance that numerous examples of those ungainly reptiles known as Crocodiles and Alligators are exhibited in the reptile house of the Zoological Society's Gardens in a living condition, while their stuffed skins and articulated skeletons are displayed in the galleries of the Natural History Museum at South Kensington, there appears to be a hopeless confusion in the public mind between these two very different creatures. And, with the usual perversity of those not acquainted with the ordinary facts of natural history, residents in India increase this confusion by almost invariably speaking of the Crocodiles of that country as Alligators, whereas an Alligator is not to be found from one end of India to another. A remarkable instance of this confusion occurs in Sir S. Baker's "Wild Beasts and their Ways," where, under the heading of Crocodile, it is stated that, "as lizards are found distributed in great varieties throughout the world, in like manner we find the largest of all lizards, the Crocodile, under various names in nearly every river of the tropics. In America this reptile is generally known as an Alligator, and some persons pretend to define the peculiarity which distinguishes that variety from the Crocodile, but I regard the distinction in the same light as that between the leopard and the panther, the difference existing merely in a name."

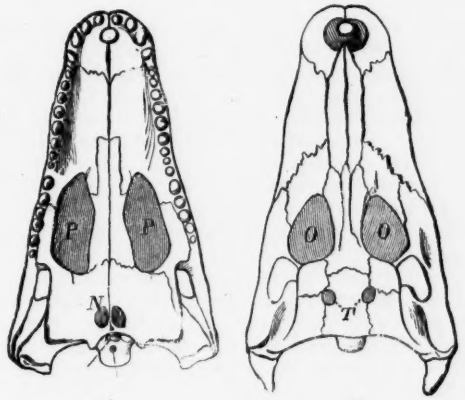
Now, in the first place, although it may be justifiable in popular language to use the term lizard as applicable to all four-footed reptiles except tortoises and turtles, yet, scientifically speaking, a Crocodile has not the slightest right to be so termed. Indeed, it would be far preferable to speak of a snake as a kind of lizard, since it is really only a special modification of the lizard stock; and from a strictly scientific point of view it would imply far less confusion of ideas to call a cow a kind of pig than to term a Crocodile a lizard, since whereas a cow and a pig are mammals belonging to the same section of a single order, lizards and Crocodiles represent two totally distinct orders of reptiles. With regard to the statement that the difference between a Crocodile and an Alligator is merely one of name, the reader who follows us through this article will probably hold a different opinion by the time he reaches the end.

So far as external appearance goes, most people are aware that Crocodiles and Alligators are large, long-tailed, low-bodied reptiles, with flat and frequently broad heads, and their bodies protected by a coat of scales, which vary greatly in size in its different regions. They probably also know that it is the impressions of these scales, or of the bony scutes by which those of the back are underlain, that form the well-known markings on the Crocodile-skin now so commonly used for bags and other leather articles. In their short and clawed limbs there are five toes in the front pair, and four in the hinder, those of the latter being connected together for a part of their length by a web. As regards their habits, Crocodiles and Alligators are typical amphibious creatures, being perfectly at home in the water, but also capable of active progress on land, on which their eggs are laid and the young hatched. The position of their external nostrils at the very tip of the snout enables them to come to the surface for the purpose of breathing without showing more than their muzzle, or, at most, this and their somewhat prominent eyes. These external characters will enable us to recognize an Alligator or Crocodile when we see it, and yet do not show us how these creatures differ so essentially from true lizards as to render it incorrect to speak of them merely as a particular group of lizards. To render this essential distinction apparent we must enter into certain details of their anatomical structure, more especially as regards the skull. Now, in the first place, a Crocodile or Alligator may be at once distinguished from every true lizard by the circumstance that its large and pointed teeth are inserted in the jaws in distinct and separate sockets, from which they will readily fall out in a dried skull; whereas those of lizards, which vary greatly in form, are invariably united by solid bone with the edges or sides of the jaws, without any separate sockets. Moreover, in a Crocodile's shell, there is a bar of bone running backwards from the lower border of the eye-socket, or orbit (Fig. 1, *O*), to join the condyle with which the lower jaw articulates. This bar is seen in Fig. 1, below,

Fig. 1.—Side view of the skull of a Crocodile; *O*, eye-socket or orbit.

and to the left of the letter *O*, and also occupying the same relative position in Fig. 3. It will further be apparent from the latter figure that in a Crocodile's skull there are two parallel bars running backwards from behind the orbit, of which the upper one is the stoutest. Now in a lizard's skull, only the uppermost of these two bars is present; and we thus have a second important distinc-

tion between a Crocodile and a lizard. A still more important difference occurs, however, in the under part of the skull. Thus, whereas in a lizard the external nostrils open directly through the palate into the front part of the mouth, in a Crocodile the bones of the palate develop a kind of flooring beneath its roof, and thus form a closed passage by which the internal or posterior nostrils are brought to the very hinder extremity of the skull. This remarkable peculiarity is well exhibited in Fig. 2, A,



A. B.

FIG. 2.—Lower view (A) of skull without the lower jaw, and (B) upper view of skull with lower jaw of a Crocodile. *O*, orbit; *T*, temporal pit; *P*, palatal vacuity; *N*, internal nostrils.

where *N* indicates the internal nostrils. The small round aperture seen in the front of the palate in both A and B is closed during life with membrane, and thus prevents any communication between the external nostrils and the front of the mouth. The object of this peculiar arrangement is to enable the animal to breathe when its mouth is open under water, and the nostrils are alone in the air; this being effected by the closing of the back of the mouth, in front of the internal nostrils, by means of a fold of skin, thus leaving a free communication between the nostrils and the wind-pipe. The advantage of this arrangement to animals which, like Crocodiles and Alligators, kill their prey by holding them under water, is self-apparent.

If to these differences between the skulls and teeth of Crocodiles and lizards, we add that, whereas in the latter the ribs articulate to the joints of the back-bone or vertebræ by means of little knobs on the sides of the vertebræ themselves, in Crocodiles they join the summits of long horizontal processes of bone projecting from the upper part of these vertebræ, we think we shall have said enough to convince our readers that it is altogether incorrect to speak of Crocodiles and Alligators as lizards. Crocodiles are, indeed, first cousins of those extinct reptiles which were described in a previous article in KNOWLEDGE as "Giant Land Reptiles," and they ought, therefore, to be regarded with respect as being the sole existing, although collateral, representatives of that great group of reptiles which dominated the earth at a time when mammals were only just beginning their career.

Having said thus much as to the distinctness of Crocodiles from lizards, we may proceed to consider how the former differ from Alligators, and to make some mention of a few of the various species of each. Now if we examine the skulls of the different kinds of Crocodiles we shall find that the number of teeth in the upper jaw varies from 17 to 19, while in the lower jaw there are invariably 15; and we shall likewise find that the teeth of the two jaws interlock with one another when the mouth is closed. Moreover, when the jaws are in opposition it will be observed that the first tooth on each side of the lower jaw is received into a pit in the palate of the skull, while the fourth lower tooth, which (like the first) is larger than the others, bites into a notch in the side of the skull (as shown in Fig. 1), and is thus more or less distinctly visible externally in the living animal. Crocodiles are now found in the rivers of Africa, India, Burma, Australia, and America, as well as in many of the larger islands in warm regions. They vary greatly in regard to the relative length of the skull, the longest-snouted species occurring in South America and West Africa, while those of India have the shortest and broadest skulls (Fig. 2). On the other hand, if we examine the skull of an Alligator, we shall find that the upper teeth bite on the outer side of the lower ones without any sort of interlocking, and both the first and the fourth lower teeth are received into pits in the skull, so that when the mouth is closed both of them are totally invisible from the outer side. Moreover, in no Alligator does the number of lower teeth ever fall short of 17. Again, in all Alligators the skull is even broader and shorter than in the Indian Crocodiles. Till within the last few years it was believed (in spite of the persistent assertion of sportsmen, that the Indian "Magars," as they are called by the natives, are Alligators) that Alligators were confined to the New World, but recently it has been found that there is one species in China. This is, indeed, a very curious instance of what is known as discontinuous distribution, and one which only finds a complete parallel in the case of the tapirs, of which there is one species inhabiting the Malay peninsula and adjacent islands, while all the others are restricted to South America. There are several species of Alligators, which are divided into two groups, according as to whether an armour of bony plates, or scutes, is or is not developed on the under surface of the body. In the true Alligators, which agree with all living Crocodilians in having a dorsal armour of these bony scutes, the number of upper teeth varies from 17 to 20, and that of the lower from 18 to 20, while there is no bony armour on the under surface of the body. The two well-known species are the Mississippi and the Chinese Alligator, in addition to which there is a third American form of which the exact habitat is unknown. The second group of Alligators, or Caimans, as they are called in Brazil, is confined to South America, where it is represented by five species. These are characterized by having from 18 to 20 upper, and from 17 to 22 lower teeth on each side, and also by having the lower surface of the body protected by a shield of bony scutes, which overlap one another like the tiles on a roof, and each of which is composed of two separate pieces united together by what is known as a sutural union.

The above, then, are the chief differences which distinguish Alligators and Caimans from Crocodiles, and they are such as surely do not justify the statement that naturalists merely pretend to distinguish between the two. Alligators and Crocodiles do not, however, exhaust the list of living Crocodilians, since we have two peculiar species differing from all the others by the great length of their snouts, and respectively inhabiting the Ganges and the rivers of Borneo—the former being known as the Gharial, and the latter as Schlegel's Gharial. In both of these reptiles the numerous teeth are long and slender, and differ from one another but little in size in different parts of the jaw, while neither of them have an armour on the lower surface of the body. They differ from Crocodiles and Alligators in feeding chiefly on fish.

XUM

In regard to their geological distribution, Crocodilians more or less closely allied to the existing Gharials, Crocodiles, and Alligators, are found throughout the rocks of the Tertiary period as far down as the London clay. Some of these extinct species were, however, of gigantic dimensions; one from the Siwalik Hills of India, which was allied to the Gharial, attaining a length of between 50 and 60 feet, and thus presenting a great contrast to living Crocodiles, which rarely exceed a length of some 22 or 23 feet. Another species found in the Tertiary clays of Hampshire presents characters intermediate between Crocodiles and Alligators, the fourth lower tooth being usually received into a pit in the skull, but the under surface of the body having a complete bony armour like that of the Caimans. This genus (*Diplocynodon*) differs from both Crocodiles and Alligators in that both the third and fourth lower teeth are larger than the adjacent ones, so that the animal had two powerful tusks in the sides of the lower jaw.

A few Crocodilians, more or less closely allied to existing types, also occur in the Cretaceous rocks, but when we reach the Wealden and Jurassic strata nearly all the forms differ very markedly from modern times, and show a lower stage of development. Before, however, we are in a position to understand how these early Crocodilians differ from their living cousins, we must enter a little more fully into the anatomy of the latter. Turning once more to Fig. 2, we see that the passage leading to the internal nostrils is formed by four pairs of bones, on the fourth of which the letter N is placed. Again, in all living Crocodilians the vertebræ articulate with one another by a ball-and-socket joint, of which the socket is situated at the front of each vertebra; this mode of articulation being the best adapted to give free motion of one vertebra upon the other. The third point we have to notice relates to the bony armour of living Crocodilians, in all of which the pitted scutes forming the shield on the back are ridged, and arranged in from four to eight longitudinal rows. Moreover, in the Caimans and the extinct *Diplocynodon*, the shield on the under surface of the body forms a single mass, made up of more than eight longitudinal rows of scutes, each of which, as already mentioned, consists of two separate pieces united together by suture.

If we now contrast these features with those obtaining in the Jurassic Crocodilians, we shall find very considerable differences. Thus in the skull of those reptiles the fourth pair of bones on the palate did not meet in the middle line below the passage to the nostrils, so that the internal nostrils were placed immediately behind, or sometimes partly between, the bones lying between PP in Fig. 2, and were thus much forwarder than in modern Crocodilians. Then, again, the vertebræ were slightly cupped at both ends, thus admitting of much less motion between one another. The armour on the back of the body is of a simpler type, consisting only of two longitudinal rows of scutes, which lack the longitudinal ridges so characteristic of those of the existing forms. On the other hand, the armour on the under surface was nearly always present and more developed, frequently consisting of two distinct portions, in the foremost of which the scutes (which consisted of a single piece) overlapped like slates, while in the hinder part they were joined by their edges to form a solid pavement of bone.

Like their modern cousins, the Secondary Crocodilians included both long-snouted (Fig. 3) and short-snouted types, the former being the more common and especially abundant in the Lias, where their remains occur in company with those of Fish-Lizards and Plesiosaurs. In many of these forms the pit (T) in the temporal region of the skull was larger than the socket of the eye, whereas in recent Crocodiles it is much smaller (Fig. 2), and in the Alligators may even disappear. A large number of these Jurassic forms were of marine habits, and a few of them attained enormous

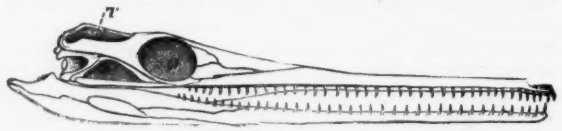


Fig. 3.—Side view of the skull of an extinct Crocodilian of the Lias; one-fourth the natural size. Letters as in Fig. 1.

dimensions, the length of the skull of one species falling not much short of five feet. A few species are further peculiar in having altogether discarded their bony armour on both surfaces of the body.

Looking at Crocodilians as a whole, it is perfectly evident that they have advanced in complexity of organization with the advance of time, the backwardly placed internal nostrils and ball-and-socket vertebræ of the modern types being clearly an advance on the Jurassic forms. As, however, is the case in many similar instances, the gradual backward shifting of the internal nostrils presents a problem difficult to understand, as it is hard to conceive what advantage the species in which these nostrils were situated in the middle of the palate had gained over reptiles in which they were placed near the muzzle, the completely backward position being apparently essential in order that the mouth might be kept open under water.

With regard to the general disappearance of the inferior body-armour and the invariably increased development of that on the back of the recent forms, it may be suggested that, as most of the Jurassic Crocodilians were of marine habits, and probably swam far out to sea, it would have been highly advantageous for them to have the lower surface of the body protected from attacks from below by sharks and other creatures. On the other hand, since modern Crocodiles and Alligators spend a considerable portion of their time on the banks of rivers, and when in the water are in the habit of reposing or crawling on the bottom, it is obvious that the back is the portion which requires especial protection. An explanation of the existence of an armour on the lower surface of the body in the Caimans is less easy to give, although it may be merely an instance of the retention of an ancestral character.

We may conclude this account by referring to some interesting observations recently made by Dr. Voeltzkow on the eggs and embryos of the Crocodile of the Nile. It appears that in Madagascar the egg-laying lasts from the end of August to the end of September, the number of eggs in a nest varying from twenty to thirty. The nest is dug about two feet deep in the dry white sand; the bases of its walls are gouged out, and into the lateral excavations thus formed the eggs roll from the slightly raised centre of the floor of the nest. Externally the nest is not discernible, but the parent sleeps upon it. The eggs differ greatly in form; the shell is white, thick, firm, and either rough or smooth, the double shell-membrane being so strong that the egg keeps its form after the shell has been removed. When newly laid the eggs are very sensitive, and are readily killed by damp or by heat, but the older eggs are hardy. When the young embryos are about to be hatched, they utter distinct notes, which the mother hears, even through two feet of sand, and proceeds to dig open the nest. Before hatching the embryo turns, and in so doing partially tears the fœtal membranes. With the tip of its snout turned to one end of the egg, the young animal bores through the shell with a double-pointed tooth comparable to that which young birds possess. This tooth appears very early—by the time the embryo is six weeks

or two months old—and may still be seen a fortnight after hatching. Through the small perforation made by this tooth the fluid flows out, softening the adjacent parts, so that the aperture is widened into a cleft. The process of creeping out may take about two hours. The young animal seems large in comparison with the egg; one measuring 28 cm. in length came out of an egg 8 cm. long and 5 cm. broad. The young Crocodiles are wild little animals, and are led to the water by the mother. They utter sounds, especially when hungry, but the pitch of their call is not so high as it was when they were within the egg.

ON THE MASS AND BRIGHTNESS OF BINARY STARS.

By J. E. GORE, F.R.A.S.

THE orbit of a binary star having been computed, and its distance from the earth determined, it is easy to calculate the combined mass of the components in terms of the Sun's mass. We can also compare the brightness of the star with that of the Sun, for as the brightness decreases as the square of the distance, we can compute how much the Sun's light would be reduced if removed to the distance of the star. Photometric comparisons have shown that the Sun's stellar magnitude is about —25·5, on a scale of which the "light ratio" is 2·512. In other words, the Sun is 25½ magnitudes brighter than a star of the zero magnitude, or 26½ magnitudes brighter than an average star of the first magnitude, like Altair or Spica. The parallax of some of the binary stars has been ascertained, and although the results found are perhaps in some cases of rather doubtful value, an examination of the mass and brightness indicated by the most careful measures of the distance may prove of interest to the reader.

We will take the stars in order of right ascension :—

1. η Cassiopeiæ.—For this well-known binary star a parallax of 0·3743″ has been found by Schweizer and Socoloff. Several orbits have been computed, none of which are quite satisfactory, but assuming Grüber's period of 195·235 years, and semi-axis major of 8·639″, I find the mass of the system equal to 0·32 of the Sun's mass. The star was measured 3·41 magnitude, with the photometer at Oxford, and 3·64 at Harvard. We may, therefore, assume its magnitude at 3·5. Taking the Sun's stellar magnitude at —25·5, I find that if placed at the distance indicated by the above parallax the Sun would be reduced to a star of magnitude 3·2, or only slightly brighter than η Cassiopeiæ. As the companion is only 7½ magnitude, it will not appreciably affect the light of the star, and as the spectrum is of the second or solar type, it should be fairly comparable with the Sun. If the mass were equal to that of the Sun, the parallax would be 0·256″, and at this distance the Sun would be reduced to a 4th magnitude star. Struve found a parallax of 0·154″. Its comparatively large proper motion of about 1·2″ per annum would indicate a comparative proximity to our system.

2. 40 Eridani.—The binary companion of this triple star is of about the 9th magnitude, and is probably physically connected with the bright star, as all three have a common proper motion. A parallax of 0·223″ has been found by Professor Asaph Hall. This, combined with the orbit computed for the binary pair by the present writer, gives a mass equal to the Sun's mass—a result which is remarkable, for the Sun, placed at the distance indicated by the parallax, would shine as a star of 4·3 magnitude, or about the brightness of the principal star of 40 Eridani. This result implies that the Sun is about 76 times brighter than the binary pair. Owing to the faintness of the binary star, the character of its spectrum has not been determined. Computed by a well-known formula, its "relative brightness" is very small, but only one orbit has yet been computed, and this will require revision when furthur measures are available. The proper motion of the system is very large, about 4·1″ per annum.

3. Sirius.—The great brilliancy of this star—the brightest in the heavens—naturally suggests a sun of great size. Recent investigations do not, however, favour this idea. Assuming a parallax of 0·39″ (about a mean of the results found by Elkin and Gill) and the elements of the orbit computed by the writer, the mass of the system would be 3·114 times the mass of the Sun. Placed at the distance of Sirius the Sun would be reduced to a star of 3·1 magnitude. As Sirius is about one magnitude brighter than the zero magnitude, it follows that it is about four magnitudes, or about forty times brighter than the Sun would be in the same position. Were it of the same density and brightness as the Sun, the mass found above would indicate that its diameter should be 1·463 the solar diameter, and its brightness 2·1324 the solar brightness. The spectrum is, however, of the first type, and the star is, therefore, not comparable with the Sun in brilliancy. The result would indicate that stars of the first, or Sirian type, are intrinsically brighter than the Sun.*

4. Castor.—Assuming a parallax of 0·198″ found by Johnson, and a period of 1001·21 years found by Doberck (a=7·43″), I find the sum of the masses of the components of Castor only 0·052692 of the Sun's mass, a result which would imply that the components are gaseous masses. Johnson's parallax is, however, of doubtful value. Placed at the distance indicated, the Sun would be reduced to a star of 4·5 magnitude. The magnitude of Castor is about 1·55, so that it is (according to the assumed parallax) about three magnitudes, or about sixteen times brighter than the Sun would be in the same position. The spectrum is of the first type, another example of the great brightness of the stars of this type. According to a well-known formula, the "relative brightness" of Castor is thirty-eight times that of the binary star, ξ Ursæ Majoris, taken as a standard. The latter star has a spectrum of the second type.

5. α Centauri. This famous star, the nearest of all the stars to the earth, as far as is at present known, forms an object of especial interest, particularly as its spectrum is, according to Professor Pickering, of the second or solar type, although with some peculiarity. Combining Dr. Gill's parallax of 0·76″ with Downing's elements of the orbit (P=76·222 years, a=17·33″), I find that the mass of the system is 2·04 times the mass of the Sun. Placed at the distance of α Centauri the Sun would be reduced to a star of about 1·7 magnitude, or about one magnitude fainter than the star appears to us. This would indicate that α Centauri is about two and a half times brighter than the Sun, and its mass (if of the same density) about four times the solar mass. As, however, there is something peculiar about the spectrum, the density and intrinsic brightness of α Centauri may be somewhat different from that of the Sun.

6. 70 Ophiuchi. This is another star which is fairly comparable with the Sun, as its spectrum is of the solar type, according to Vogel. The orbit found by the present writer (P=87·84 years, a=4·50″), combined with Krüger's parallax of 0·162″, gives for the combined mass of the components 2·777 times the mass of the Sun. The star was measured 4·11 magnitude with the photometer at Harvard Observatory. Placed at the distance indicated by the

* Or that they are of less density than our Sun.—A. C. RANYARD.

parallax, the Sun would be reduced to 5·0 magnitude. This would make 70 Ophiuchi about 2·27 times the brightness of the Sun. According to Dembowski there is a difference of 1·7 magnitude between the components. If we assume that each has the same density as the Sun, I find that the combined mass of the two stars would be 2·825 times the solar mass, which agrees closely with the result found from the orbit. We may, therefore, conclude that Krüger's parallax for this star is not far from the truth. The diameters of the components would be about 1,188,000 miles, and 542,000 miles, and the distance between them 27·77 times the Sun's distance from the earth, or somewhat less than the distance of Neptune from the Sun.

7. 85 Pegasi.—For this binary pair, a somewhat doubtful parallax of 0·054″, found by Brünnow, combined with Schaeberle's elements of the orbit (P=22·3 years, a=0·96″), gives a mass of 11·3 times the Sun's mass. Placed at the distance indicated, the Sun would be reduced to a star of 7·41 magnitude. 85 Pegasi was measured 5·83 magnitude with the photometer at Harvard, so that the star is 1·58 magnitude, or 4·286 times brighter than the Sun would be at the same distance. If of the same density, its mass would, therefore, be 8·872 times the solar mass, a result not differing very widely from that found from the orbit. As, however, I have no information of the character of the star's spectrum, I cannot say whether or not it is comparable with the Sun.

It seems to be still very doubtful whether 61 Cygni is really a binary star, but assuming a parallax of 0·45″, and the star's magnitude at 5·11, as measured at Harvard, I find that the Sun is about 8·39 times as bright as 61 Cygni, and its mass, therefore, considerably greater. The star has, according to Professor Pickering, a peculiar spectrum of the solar type.

Let us now consider the close binary stars recently discovered with the spectroscope, and which are known as "spectroscopic binaries." With reference to Algol, which may be considered as a binary pair, in which one of the components is a dark body, Professor Vogel finds that the combined mass of the system is about two-thirds of the Sun's mass. From the dimensions he gives for the components, I find that their mean density is about one-third that of water, so that they are probably gaseous bodies. As the parallax of this star has not yet been determined, we cannot say what the Sun's magnitude would be if placed at the star's distance, but as the spectrum of Algol is of the first or Sirian type, we may conclude that it is bright in proportion to its mass.

For ζ Ursæ Majoris (Mizar) Professor Pickering finds a mass equal to forty times the mass of the Sun. Klinkerfues found a parallax of about 0·045″ for this star. At this distance the Sun would be reduced to a star of only 7·8 magnitude. The Harvard measure of ζ Ursæ is 2·38. It is therefore 5·42 magnitudes, or 147 times brighter than the Sun would be at the same distance. It should therefore be, if of the same density, 1787 times the mass of the Sun. But the spectrum is of the first type, and the star is therefore not comparable with the Sun in its physical constitution. We have here another example of great brightness in proportion to mass.

β Aurigæ was discovered to be a close binary with the spectroscope at Harvard Observatory, and the discovery has been fully confirmed by the observations of Professor Vogel at Potsdam. The period is about four days, and the distance between the components about 16 millions of miles. From these data I find that the mass of the system is about five times the mass of the Sun. Recent photographic measurements by Professor Pritchard at Oxford have yielded a parallax of 0·059″ and 0·065″ (*Observatory*, June, 1891). Taking a mean of these results, or 0·062″, we have the Sun reduced to 7·17 magnitude if placed at the distance of the star. β Aurigæ was measured 1·94 magnitude at Oxford and 2·07 at Harvard. We may therefore assume its magnitude at 2·00. This gives a difference of 5·17 magnitudes between the light of the Sun and that of β Aurigæ. In other words, β Aurigæ is 117 times brighter than the Sun would be if placed in the same position. If therefore of the same intrinsic brightness of surface its diameter would be 10·8 times the diameter of the Sun, and its volume 1265 times the Sun's volume. We see, therefore, that—like Sirius—this star is very much brighter than the Sun in proportion to its mass. As the spectrum of β Aurigæ is of the first or Sirian type, we have here another example of great brilliancy in proportion to mass, a feature which seems characteristic of all stars of the Sirian type.

Spica.—The spectroscopic observations of this bright star indicate a mass of about two and a half times the mass of the Sun. The parallax has not yet been well determined (Brioschi found a negative parallax), but judging from its small proper motion, the star's distance is probably very great. As it is a standard star of first magnitude, its brightness would seem to be enormous in proportion to its mass, and here again we have a spectrum of the Sirian type.

We may therefore conclude that binary stars with spectra of the first type—and probably all stars of this type—are very bright in proportion to their mass, while those showing spectra of the second or solar type are intrinsically much less luminous and have a brightness approximately proportional to their mass.

[Many of the parallaxes made use of by Mr. Gore in these calculations are no doubt extremely doubtful. But in such an enquiry, even the roughest estimates are of value. The evidence collected tends to indicate that stars of the Sirian type are either less dense than the Sun—that is, that they are in an earlier stage of condensation—or that their photospheres are more brilliant, area for area, than the solar photosphere.—A. C. Ranyard.]

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

PERMUTATIONS AND COMBINATIONS.

To the Editor of Knowledge.

Dear Sir,—It has occurred to me that the solution of interesting questions concerning the number of possible changes or permutations in the arrangement of things is often rendered impossible to most persons in consequence of the great labour involved in the mere arithmetical process of computation. I am quite aware that the higher mathematics has furnished us with a formula, including functions of π and ϵ, by means of which the factorials of high numbers are obtainable with as great a degree of exactness as the use of logarithms will afford; but, when very great numbers are under consideration we never want exactness—nor could we obtain it if we did. Some numbers are so bewilderingly vast that it would take years even to write them down in figures; such numbers can only be apprehended by means of their logarithms, or, which comes to the same thing, by the statement how many figures they take. The same thing applies, though in a less degree, to numbers not quite so enormous. When

we are told a certain number of things can be arranged in more than a decillion of ways, or, in mathematical language, that the factorial of a certain number is upwards of a decillion, our curiosity is equally satisfied in being told that the number would take more than 60 figures to write it down; which, again, is the same thing as saying that its logarithm is greater than 60. Such being so, all we really require in these cases is a simple formula, by means of which we can obtain the integral part of the logarithm—the error being only in the fractional part.

Such a formula I think I have discovered, but whether already known I cannot say. It may briefly be stated thus:—That the factorial of any number n is approximately, in the above manner, equal to

$$(\cdot 37\ n+1)^n$$

This formula may be used, say from 13 to 650.

To show that this is really the case, I give below the logarithms of a few factorials, together with those of the corresponding values by the formula.

Number.	Log. of Factorial.	Log. of Formula.	Diff.
13	9·79	9·93	0·14
16	13·32	13·42	0·10
21	19·71	19·80	0·09
40	47·91	47·95	0·04
81	120·76	120·77	0·01
100	157·97	157·98	0·01
300	614·49	614·77	0·28
600	1408·10	1408·98	0·88

When the factorials of numbers *greater* than 650 are required, it is better to substitute ·368 for ·37 in the formula. This will give a more extended range; thus—

Number.	Log. of Factorial.	Calculated with ·368.	Diff.
1000	2567·60	2567·03	−0·57
1100	2869·73	2869·14	−0·59
1500	4114·68	4114·09	−0·59
5000	16325·58	16325·27	−0·31
7500	25808·09	25808·00	−0·09
9000	31681·91	31681·99	+0·08
10,000	35659·45	35659·66	+0·21
11,000	39680·50	39680·83	+0·33

Between 15,000 and 20,000 the error commences to extend into the characteristic or integral part of the logarithm. Accordingly, if the same nearness is required for still greater numbers, another fraction would have to be substituted for ·368. But for most purposes I should imagine that either ·37 or ·368 will serve.

T. S. BARRETT.

[Mr. Barrett's useful formula will be more readily remembered by observing that it approximates, when n becomes very great, to $(\frac{n}{e}+1)^n$. This may be easily proved from De Morgan's formula* for $1\times2\times3\times\ \ldots$ up to n—$[n=\sqrt{(2\pi n)}\ n^n\ \varepsilon^{-n+\frac{1}{12n}-\frac{1}{360}\frac{1}{n^3}+}$—A. C. RANYARD.]

ON THE RED STARS NEAR THE CYGNUS NEBULA, DETECTED BY DR. WOLF.

To the Editor of KNOWLEDGE.

SIR,—The very remarkable photographs of Dr. Max Wolf of the region about α Cygni, showing a large mass of nebulous light, and your interesting article published in the October number of KNOWLEDGE, led me to compare the photographs with the charts of Argelander. Any red star would at once be recognizable, on account of the difference between its actinic light and its brightness as seen with the eye. All stars showing any such difference were marked on the charts, and subsequently examined with the telescope. The region is not abnormally rich in known red stars. Only three fourth-type stars have hitherto been detected in this region; two others are suspected to be of type IV. The red region of Cygnus lies somewhat to the south of the α Cygni photograph, and all the Wolf-Rayet stars, save one, are also to the south. The telescope used was a 17¼-inch reflector, with a power of 70, and where there was sufficient light the stars were examined with the spectroscope, but no new fourth-type stars were detected, though several new third-type stars were discovered. The work was carried on during the evenings of September 9th, 10th, 29th, October 1st, 2nd, 3rd, after I had first seen a print of Dr. Wolf's photograph lent me by Mr. Ranyard, and in all 159 stars were examined. The classification by colour is the same as that used throughout the "Red Star Catalogue." The following red stars were detected:—

Red and orange red	23	
Pale orange red	38	
Slightly tinged with red	36	Total 97

The remaining stars show nothing of interest, being usually fainter than the 9·5 magnitude of Argelander. Nine stars, however, are now only of the 11·0 magnitude, or less, and several, if not all, will probably turn out to be variable. The boundaries of the smaller photograph are in right ascension 20h. 14m. to 21h. 0m. roughly, and in declination + 39° to + 50°. The number of stars in Argelander is 3011. On page 194 of the "Red Star Catalogue," a method is given of finding the probable number of red stars; this is, number of stars × ·0075. Multiplying the number of stars in Argelander by this quantity, we get 23, which accords exactly with the number of stars actually observed. It would seem, therefore, that there is no abnormal quantity of red stars in this region. In the next place, the whole of the stars which showed any colour were marked with red on the photographs to see if they were distributed according to any rule. Only one star, and this pale orange red, was found in the nebula. Generally speaking, the coloured stars seem to lie on the borders or between the groups or streams of stars. A curious and slightly curved line of four nearly equidistant coloured stars extends from α Cygni to the preceding edge of the photograph. Another curve of five stars is associated with γ Cygni. The north part of the photograph, especially where the stars rapidly decrease in number, seems richer in coloured stars, and on extending the sweeps yet further north this fact is very obvious. As regards the minute stars, I am inclined to believe that none are beyond the range of the 17¼ reflector. The *minimum visible* of the 17¼ has been found to be 15 magnitude on Argelander's scale, and though only one field has been examined, yet from the results it would seem that the smallest stars are within the limit of 15 magnitude. Only three red variable stars known at the present time lie in this region, two of them following α Cygni, and north of it; still further to the north and on the following side of the photograph, but beyond it, lie three other variable stars. Finally, the brighter stars in the immediate vicinity of the nebula were examined with a powerful spectroscope, and seen to be generally first-type, with strongly marked hydrogen lines. It was thought possible that some of them might show bright lines, as in the case of stars associated with the nebula in Orion, but no such star was detected. The nebula is visible in the 17¼, as a faint haze.

Towlaw, Darlington. T. E. ESPIN.

[I hope in a future number to give a photo-etching of the stars in the α Cygni region with Mr. Espin's new red stars marked upon it. I should be glad if other observers with large telescopes would compare the stars they can see in this region with those shown in the plate

* *See* De Morgan's "Differential Calculus," p. 312.

published in the October number of Knowledge. I have only had an opportunity of examining the region under unfavourable circumstances with an 18-inch reflector. It seemed to me that the photograph showed many more faint stars than I could reach with the telescope, and I could only detect the brightest parts of the nebulous regions.—A. C. Ranyard.]

To the Editor of Knowledge.

Sir,—There is some confusion in your September and October numbers with reference to the magnitude of Canopus: the magnitude 0·4 quoted in the list on p. 91 is on the *Uranometria Argentina scale*: the magnitudes of the other stars, except α Centauri, are on the scale of the Harvard Photometric Catalogue, and the two scales are not comparable. Herschel's magnitudes are evidently not photometric, and this introduces a new scale, and accounts for the apparent faintness of Sirius. Thome gives the magnitude of Canopus in 1885 as −0·6 with Zöllner's Photometer. The agreement is therefore complete as to Canopus being the second brightest star in the heavens.

In the October number, page 193, 2nd column, line 8, "ζ Cancri" should read "S Cancri."

Yours truly, T. W. Backhouse.

THE UPPER ATMOSPHERE.

By A. C. Ranyard.

I AM enabled this month, through the kindness of Mr. Shadbolt, to lay before the readers of Knowledge some photographs taken from balloons at various altitudes. Mr. Shadbolt is a very experienced amateur aeronaut who has made over sixty ascents, and he was, I understand, the first to take a recognizable photograph from a balloon, in June, 1882. The rays of light which fall on a photographic plate exposed from a balloon have had to pass twice through the densest and most dust-laden strata of the atmosphere. Even in photographing distant landscapes from the surface of the ground very little detail is ordinarily obtained upon distant hills, owing to the absorption of the photographically active rays in passing through a great distance of the lower atmosphere. But the difficulty is greatly increased in attempting to photograph the distant earth from a great altitude in a balloon, for not only is the absorption increased by the long course of the rays through the lower air, but the observer sees the dust-motes in the atmosphere from their sun-illuminated side. The veil of haze spread over the earth, therefore, hides the objects behind it more effectually than the transparent veil of haze which we ordinarily see over a distant landscape, giving the soft effects of distance which artists so well know.

An observer with a giant telescope, on Mars or on the Moon, would probably see much less of what is going on on the surface of the earth than we are apt to imagine. The white upper surfaces of the clouds would first attract his attention, with, in between them, a very dim and hazy view of objects on the earth's surface, rendered all the more difficult to observe by the frequent presence of a dazzlingly bright patch of sunlight reflected from the sea. To a naked eye observer on Mars, the earth would probably appear like a variable star, with a curious and mysteriously irregular period of variation, due to the change in the brightness of the specularly reflected patch of sunlight as terrestrial clouds covered it up, or the rotation of the earth brought continents or seas to the part of the earth's surface from which specular reflection could take place.

The exposure of photographs taken from a balloon must necessarily be short, for the balloon generally drifts along with considerable velocity, and sometimes it revolves. The revolution is, however, never very rapid, and it is generally more noticeable as the balloon descends than as it rises, owing to the greater irregularity of the car and under-surface of the balloon as compared with the comparatively spherical surface which it presents to the air on rising. With reference to the velocity with which balloons travel, Mr. Shadbolt is of opinion that they do not, as a general rule, travel so rapidly when at a considerable altitude as they do when nearer to the earth. Since this is contrary to the usually received opinion with regard to the velocity of the wind at various altitudes, and Mr. Shadbolt's judgment is founded on very full notes which he takes, during his balloon voyages, as to the time of passing over various places, I give the following extract from a letter he obligingly wrote me on the subject. Mr. Shadbolt says: "I have invariably found the wind near the earth, say up to 1500 or 2000 feet, to be stronger than at higher altitudes. I have frequently mounted up to take refuge from an approaching squall, and it has overtaken the balloon and passed below it, while nearly always when above the clouds they appear to travel along at a more rapid speed, and to pass along beneath the balloon. The same thing is noticeable when there are no clouds; you take your bearings and scarcely seem to be moving until you drop down near to the earth. Some might say that this would naturally be due to the distance you are from the objects below, making a quick movement appear to be slow, but after some practice you learn to recognize the actual rate at which you are passing over the ground below you."

At considerably greater heights in the air than balloons have ever attained to, the wind is known occasionally to blow with a velocity of over 140 miles an hour. Thus the dust from the explosion of Krakatoa, which took place on 27th August, 1882, was carried to the West India Islands (half round the earth) in seven days, and the average velocity of the wind at mountain observatories greatly exceeds the average velocity observed at the sea level. A passenger in a balloon hardly feels the wind from the time he starts till the time he touches earth again, for though a high wind may be blowing he is carried along with it, and only feels a slight wind when the balloon, in rising or falling, passes from one current into another, and then the sensation only lasts until the balloon has taken up the velocity of the current of air into which it has passed. The greatest altitude which has been attained by a balloon seems to be a little over seven miles. Mr. James Glaisher and Mr. Coxwell ascended from Wolverhampton on the 5th September, 1862, and are believed to have reached an altitude of 37,000 feet, at which height the barometer would only stand at seven inches. Mr. Glaisher's last reading in ascending was made at a height of 29,000 feet, after that he became insensible, and Mr. Coxwell, at the greatest height attained, lost the use of his hands, and was obliged to pull the cord (which opened the valve and caused them to descend) by seizing it with his teeth and bowing his head downward.

The altitude attained by Messrs. Glaisher and Coxwell, though higher than the highest mountain, sinks into insignificance compared with the total height of the ocean of atmosphere which surrounds the earth. Small clouds may occasionally be observed at a height of ten miles*

* Mr. H. P. Curtis, of Boston, tells me that the towering cumulus clouds over thunderstorms on the American prairies may sometimes be seen on the horizon at a distance of 200 miles; proving that they occasionally attain an altitude of over five miles.

XUM

1.—**Taken from a Balloon** by Mr. CECIL V. SHADBOLT, at a height of 500 feet over Silvertown. Shows the Thames and Woolwich Dockyard buildings in the foreground, with a distant view over Kent. 13th August, 1884.

2.—**Taken from a Balloon** by Mr. CECIL V. SHADBOLT, at a height of 6000 feet over Belvedere. Shows the Thames in the foreground, with jetty running out into the river. 17th August, 1889.

The Automatic Engraving Company, Limited,
Strode Road, Willesden Green.

3.—**Taken from a Balloon** by Mr. CECIL V. SHADBOLT, at a height of 2100 feet over Lewisham (reversed right and left).

4.—**Taken from a Balloon** by Mr. CECIL V. SHADBOLT, at a height of 1500 feet over Beckenham (reversed right and left).
1st August, 1887.

XUM

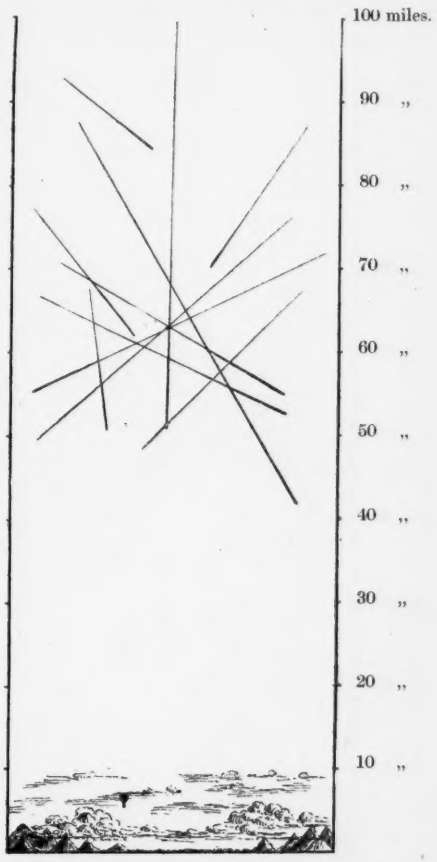
XUM

above the sea level; and observations of the duration of twilight show that a glimmer of light may generally be traced till the sun is 18° below the horizon, which indicates that there is matter capable of dispersing the sun's light at an altitude of about 40 miles. On ordinary occasions the air above that altitude is either too rare, or too pure from foreign particles, to disperse any perceptible amount of twilight. After the explosion of Krakatoa the sunset colours and the longer duration of twilight showed that dust was suspended in the upper atmosphere for many months, at considerably greater altitudes than usual, probably at a height of at least 60 miles. It has been suggested that the volcano threw the dust to an altitude of a few thousand feet, and that it was then carried into the upper air by the rising heated atmosphere of the tropics, which always gives rise to an upcast current carrying the air from near the surface of the ground to a great altitude, and dispersing it and the dust it contains north and south into either hemisphere. But as similar sunset effects were observed in the last century extending over Europe after the great eruption of Skaptar Jokul in Iceland,* it is probable that the heated column of air over the volcano itself would be sufficient to carry dust into the higher regions of the atmosphere.

The smaller shooting stars generally become visible at a height of from 70 to 80 miles above the earth, and they are usually entirely consumed before they penetrate to 50 miles above the sea level, but there is ample evidence that larger meteors have occasionally been observed at a height of over 100 miles above the earth's surface, proving that there is sufficient atmosphere at such great altitudes to resist their motion and convert a part of their energy of translation into heat and light sufficient to render them visible.

The air at these great altitudes must be very rare, much rarer than the vacuum within the bulb of an electric incandescent lamp, for the density of the atmosphere is halved at a height of about three and a half miles, and we know that with an atmosphere composed of gas, which obeys Boyle's law connecting the density with the pressure, the density will continue to be halved with every additional ascent of three and a half miles; consequently at a height of 70 miles the density will have been reduced in the proportion of 1 to 2^{20}, that is, the atmosphere will have less than a millionth of the density of the air at the sea level, which about corresponds to the density of the air within the bulb of an electric lamp (usually spoken of as the vacuum). At a height of 105 miles the density of the air will have been reduced in the proportion of 1 to 2^{30}, or more than a thousand million times.

The reason for this rapid decrease in geometrical progression of the density of the atmosphere as we ascend is easy to see when we consider the pressure on each stratum of three and a half miles in thickness as we rise above the earth's surface. The lowest stratum, which contains a half of the atmosphere, is compressed by the weight of the upper half of the atmosphere that rests upon it. The next quarter of the atmosphere will occupy a stratum of the same thickness as the lowest half of the atmosphere, because every part of it will be compressed with just half of the weight which compresses a similar stratum of the lowest half, and the atmosphere is composed of gases which very approximately obey Boyle's law; that is, the volume varies inversely as the pressure. In the same manner the third stratum of three and a half miles in thickness will contain an eighth part of the whole atmosphere under the pressure of the weight of the remaining eighth part above it, and the fourth stratum will contain a sixteenth part under the pressure of the weight of the remaining sixteenth part, and so on.



The successive steps at which the density of the earth's atmosphere is halved will in fact become shorter and shorter as the temperature falls in the upper air, for the volume occupied by a mass of gas depends upon its temperature as well as the pressure upon it. While the pressure remains constant the volume varies as the absolute temperature. Thus, if the height of the lower half of the atmosphere at a temperature of 32° Fahr., or 0° Cent., were exactly three and a half miles, its height at a temperature of T degrees would be $\frac{T}{273} \times 3{\cdot}5$ miles, where T is the absolute temperature measured in degrees Centigrade. We know that the temperature falls very rapidly in the upper air; thus, at the greatest height reached by Mr. Glaisher on the 5th September, 1862, the temperature of the air as registered by a minimum thermometer fell to —11·9° Fahr., at a height where the pressure of the atmosphere was only reduced to about a quarter of the pressure at the sea level. If at a height of 70 miles the temperature falls to −91° Cent., the height of the successive steps of the above series will be reduced to two-thirds of the height of the lowest half of the atmosphere—that is, the density of the atmosphere would be halved at successive steps of a little less

* Gilbert White, of Selborne, in one of his letters to the Hon. Danes Barrington, describes "the amazing and portentous phenomena" observed in the summer of 1785. He says the sun "shed a rust-coloured ferruginous light on the ground, particularly lurid and blood-coloured at rising and setting." There are many references to the "red fog" which caused great alarm over Europe during the whole of the summer of 1783. Lalande ascribed it to the effect of a hot sun succeeding a long period of heavy rains, and Cowper refers to it in "The Task," Book II., lines 53-65, which were written in the autumn of 1783; he also refers to the earthquakes and tidal waves of that year. Mrs. Somerville, in her "Physical Geography," traces the origin of these phenomena of 1783 to the great eruption of Skaptar Jokul, which broke out on May 8th and continued till the end of August, sending forth immense quantities of dust as well as lava. Sir John Herschel, in his "Physical Geography," states that Skaptar Jokul ejected 21 cubic miles of lava, a quantity equal to the volume of water poured by the Nile into the sea in a year.

than two and a half miles, so that we have considerably under-estimated the actual rate of decrease of the density of the atmosphere on mounting upwards.

Let us assume that the density of the air at a height of 100 miles is reduced to a thousand-millionth of the density of the atmosphere at the sea level, we are still very far from having got rid of the atmosphere altogether. According to recent estimates, founded on curious corroborative evidence derived from more than one class of physical phenomena, a cubic inch of such tenuous atmosphere would contain about 350 thousand million molecules of gas; a number which is so enormous that its vastness can only be partly realized by means of an illustration. Let us suppose a small bulb of one inch cubic capacity to be filled with air of a thousand millionth, the density of atmospheric air at the sea level. If the bulb were imperfectly sealed so that a thousand molecules could rush into it in every second of time, it would take more than eleven years for the pressure inside the bulb to become doubled—that is, for as many more molecules to rush through the leakage as were originally contained in the bulb.

If the pressure of the air continues to decrease according to the same law, as we proceed upwards its density will have been decreased to one million million millionth part of the density at the sea level at a height of 200 miles, and a cubic inch of such air would contain only about 350 molecules; and at a height of less than 222 miles, a cubic inch would only contain one molecule.

At what height should we reach the surface of the atmosphere? Many people, whose opinions are entitled to respect, have thought that the air has not an upper limit. Professor Young, in his "Text-book of General Astronomy," in dealing with the height of the atmosphere (sec. 98), is cautious, and says that it cannot "be asserted positively that the atmosphere has any definite upper limit." But Professor Förster, of Berlin, in a paper which he read before the German Geographical Society* in May last, brings together evidence which he thinks proves the existence of a "Himmelsluft," or thin air pervading in greater or less density the whole of the solar system, and which he assumes is associated with the strata of extremely rarefied gases, which follow the earth's movements round the sun. He quotes, as evidence of such a medium, the retardation of Encke's comet when near to perihelion, and the appearance of the zodiacal light and the "gegenschein," or "counterglow," which has been so frequently observed, as well as some other evidence which appears to be very doubtful with regard to the height of luminous clouds and the aurora.

The retardation of comets near to perihelion may be satisfactorily accounted for by the great extension of coronal matter about the sun, and the appearance of the zodiacal light and the "gegenschein" may be due to the light dispersed by flights of meteors which seem to be aggregated near to the plane of the ecliptic and not to be evenly dispersed about the sun, as would be the case if an atmosphere filled inter-planetary space. But the kinetic theory of gases seems to afford evidence that the molecules of the atmosphere do not escape from the region of the earth's attraction. According to the kinetic theory the molecules of hydrogen, at a temperature of 0° Cent., move with an average velocity of a little more than 6000 feet per second. Clerk Maxwell, in his "Theory of Heat," 9th edit., p. 314, gives their average velocity as 6097 feet per second. The atomic weight of nitrogen is 14·01; consequently, assuming Clerk Maxwell's velocity for hydrogen, the molecules of nitrogen at a temperature of 0° Cent. will move with an average velocity of 1629 feet per second, and the molecules of oxygen, the other chief constituent of the atmosphere, will move a little more slowly. The square of the mean velocity varies as the absolute temperature; consequently, as the temperature is lowered the average velocity of the molecules decreases rapidly, and we may feel quite confident, from observations made in balloons and at mountain observatories, that the temperature near to the limits of the atmosphere is far below 0° Cent. We shall therefore be certainly much above the mark in assuming an average velocity of 1629 feet per second for the molecules of nitrogen in the highest strata of the atmosphere, where their free path becomes very long, and some of them can escape upwards without suffering a collision. A projectile thrown upwards from such an altitude under the influence of the earth's gravity, with a velocity of 1629 feet, would be carried to a height of less than nine miles above the point at which it started and would fall again into the atmosphere. It would require a velocity more than twenty-two times as great, or of about seven miles per second, to carry it away from the earth. The velocities above referred to are the mean velocities of molecules at a temperature of 0° Cent. We know that the actual velocities of the molecules will be distributed about the mean velocity according to the law of probable error, and it seems very improbable that in the extremely cold upper regions of the atmosphere any molecules will have a sufficiently great upward velocity to be carried outside the region of the earth's attraction.

* An abstract of this paper is printed in the "Proceedings of the Royal Geographical Society of London" for July, 1891.

Notice of Book.

On the Adjustment and Testing of Telescopic Objectives (published and sold by T. Cooke and Sons, Buckingham Works, York; price 5*s*.).—This little book will be greatly welcomed by observers, as teaching them how to adjust and test the adjustments of their object-glasses and mirrors. The illustrations are excellent, particularly the frontispiece, which shows the various appearances of star discs as seen in and out of focus, with perfect and defective object-glasses, and with a good instrument when badly adjusted. The authorship of the work is not stated; it appears to be a joint production of persons possessing very considerable practical as well as theoretical knowledge.

METEOROLOGY OF BEN NEVIS.

By Dr. J. G. McPHERSON, F.R.S.E.

(*Lecturer on Meteorology in the University of St. Andrew's.*)

BEN NĔVIS, in Inverness-shire, is not only the highest mountain in Scotland, but also the highest in the British Islands. It is comparatively easy of ascent, and its west side is nearly precipitous. Fort William, an old military town at its western base, is on the sea coast. Some years ago this mountain was considered exceptionally advantageous for observations at its summit and base for the pressure and temperature of the air, and for the direction of the wind at a difference of above 4000 feet level. Accordingly Mr. Wragge made arrangements for observations from June to October during the three years 1881—83. Since that time improvements were made in the buildings on the summit; telegraphic communication was made between the summit and base of the mountain; and Mr. Ormond

and others have for the past seven years made very careful observations during the whole year.

Dr. Alexander Buchan, the secretary of the Scottish Meteorological Society, has recently published in the Journal of the Society an outline of the observations made at the Ben Nevis Observatory and at Fort William during that period, and again in the "Transactions of the Royal Society of Edinburgh." From this account we find that for that period the mean barometric pressure at the height of 4407 feet (the top of the Ben) is 25·294 inches, and that the mean barometric pressure at sea level (Fort William) is 29·856 inches, the difference being 4·562 inches, or about an inch to the 1000 feet of difference of level. The difference reaches the maximum of 4·641 inches in February, and the minimum of 4·484 in July.

The mean temperatures at the top and bottom are 30·9° and 46·8° Fahr. respectively, the difference for 4407 feet of altitude being 15·9°. The difference reaches the maximum of 18·5° in April, and the minimum of 13·9° in January. The absolutely highest temperature at the Observatory was 67·0°, on June 24th, 1887, and the lowest, 6·4°, on February 10th, 1889.

The mean annual rainfall at the Observatory has been 140·17 inches, and at the base 78·19 inches; or 61·98 inches less at the base than at the top of the Ben.

The direction of the winds on the Ben indicates a well-marked diurnal variation. From 3 a.m. to 8 a.m. northerly winds (strength $2\frac{1}{2}$ miles an hour) prevail, whereas from 11 a.m. to 2 p.m., southerly winds (a little stronger) are in the ascendant. The coldest wind is from the north-east and the warmest from the south.

The electrical phenomenon, called St. Elmo's Fire, is often observed on the Ben, especially during the winter months. The weather which precedes, accompanies, and follows this phenomenon has quite marked characteristics. Stormy weather is called at the Observatory "St. Elmo's weather," so peculiar is it. In almost every case another cyclone, with its spell of bad weather, follows the particular cyclone in which St. Elmo's Fire is observed. Seventy per cent. of the thunderstorms occur from September to February, being very rare in summer—the very reverse of what occurs in the east of Scotland. But at Fort William summer thunderstorms are twice as frequent as at the Observatory, suggesting that a considerable number must be below the summit. The winter thunderstorms prevail at night; the reverse is the case in summer.

Professor C. Michie Smith has shown that, on the edge of a dissolving mist, the potential is lower than the average, but higher on the edge of a condensing mist. This is corroborated by the observations on Ben Nevis. When the top of the Ben becomes clear for a short time, a strong current comes up the telegraph wire from the base to the summit. But as soon as the summit is again mist-clad, the current is reversed. During a fall of rain the current nearly always passes down the wire; and in a sudden shower this current is very strong. When the rain stops the current passes upwards again.

Some very curious results are given about the enumeration of the dust-particles of the air, by means of the ingenious apparatus invented by Mr. John Aitken, of Falkirk. This apparatus we described in the October number of KNOWLEDGE last year. On 31st March of last year, at 4.30 p.m., the summit of the Ben was clear, and the number of dust-particles per cubic inch was 46,400, but shortly afterwards a thickness was observed approaching from the south-west, which by 6 p.m. reached the Observatory, and the dust-particles rose to 214,400 per cubic inch—the maximum observed since. On June 15th the number fell from 15,600 at midnight to 840 at 10.30 a.m.

But the observations on the 20th July were exceptionally remarkable. At Fort William the thermometer remained constant at 55° from 9 p.m. till 4 a.m. next day. But at the top there was a most marked variation of temperature. At 10 p.m. the wind suddenly veered from south-west to north, increasing to 40 miles an hour, and the temperature rose from 41° to 47°, and soon after to 49·2°. Ten observations were made with Aitken's dust-enumerator, between 2 and 3 a.m., and the extraordinarily low mean of only 34 dust-particles in the cubic inch was registered. From our last notice it will be found that 3500 per cubic inch is the lowest figure ascertained by Mr. Aitken, and that was in Switzerland. The peculiarity of this minimum register on the Ben is thus accounted for. A warm highly-saturated north wind was blowing out of the cyclone, which lay to the northward; whilst the sea-level wind, which was south-west, was blowing in upon the same cyclone. It is evident, then, that there is an intimate relationship between the number of dust-particles and the cyclones and anti-cyclones over North-Western Europe at the same time.

Halos, coronæ, fog-bows, glories, and other optical phenomena hold a prominent place among the observations on the Ben. But the most laborious investigation has been the determination of the rate of diminution of temperature with height, and the rate of the diminution of pressure for the different air-temperatures and sea-level pressures that occur.

BIRDS AND BERRIES.

By the Rev. ALEX. S. WILSON, M.A., B.Sc.

(*Continued from page* 132.)

THERE are a few cases in which fruits though not succulent appear to depend on birds for the dispersion of their seeds. The snake-nut of Demerara (*Ophiocaryon paradoxum*) is so called on account of its peculiar coiled embryo presenting a striking resemblance to a small snake. The likeness is so marked that when the egg-like capsule is opened, one involuntarily starts back from the supposed reptile. It would seem that the imitation here is intended as a deception; for if a bird seizes the seed under the impression that it has got a snake, and after carrying it some distance discovers its mistake and lets it drop, then the object of the plant—dissemination—has been attained, and that without any outlay in the shape of succulent pulp or saccharine matter. In like manner the pod of *Scorpiurus subrillosa* has a curious resemblance to a centipede, and that of *S. vermiculata* to a worm or caterpillar. The long hanging pods of *Trichosanthes anguina*, as its name indicates, look very much like snakes. *Biserrula pelecinus* resembles a centipede. According to Lubbock, the seeds of *Abrus precatorius*, *Martynia diandra*, *Jatropha* and *Ricinus* mimic beetles, while several lupines have seeds resembling spiders.

The advantage of the mimicry in the rosary bean (*Abrus*) is easily understood. The beans are bright scarlet with a black, glossy patch. When the pod dehisces they are exposed to view and attract, we shall suppose, an insectivorous bird which mistakes them for a particular kind of beetle. After carrying the bean some distance the bird discovers its error, drops the seed, and thus gratuitously accomplishes the dissemination of *Abrus*. The seeds of *Clerodendron* also appear to be mimetic, and remind one somewhat of the rosary bean. Possibly this explanation also applies to the common cow-wheat, the

seed of which has a marked resemblance to the larva of an insect. The black shining seeds of a large number of plants, of columbine among others, might easily be mistaken for minute beetles, and the similarity may be of advantage in the manner indicated.

The fertilization of flowers and the dispersion of seeds are, of course, services unconsciously rendered so far as the insects and birds are concerned. There is the exceptional case of the Yucca moth, which deliberately pollinates the flowers on the seeds of which its larvæ feed. To this there would appear to be a curious parallel; for it is alleged that in Guatemala a bird has the remarkable habit of picking holes in the bark of a certain tree, and depositing therein the seeds of a parasitic plant on the berries of which it feeds.

Dispersion through the agency of birds is attended with certain advantages. The necessity for dispersion appears to be common to all plants; but this mode affords facilities for the transport of seeds across mountain ranges and arms of the sea, such as would prove effectual barriers to wind-borne seeds unless those of infinitesimally small dimensions. Birds are more likely to deliver the seeds in localities corresponding to the habitats of the plants. The maceration of the seeds in the bird's stomach in some cases appears to facilitate germination. This mode of dispersion is also preferable to wind agency where the number of individuals composing the plant species is limited, since fewer seeds will be lost or destroyed.

It is not very easy to account for the origin of these special provisions favouring dispersion by birds. The colours and sweet tastes of fruits as well as certain properties of the seeds might, no doubt, be referred to variation and natural selection. Possibly these may have arisen very much in the way that Darwin supposed the adaptation of flowers to insects to have been brought about. The pollen of primitive wind-fertilized flowers might, he thought, at first induce insects to visit them. The presence of nectar he explained as due in the first instance to the accidental appearance within the flower whorls of a sweet secretion occasionally exuded from various parts of plants, such as from the leaves of the common laurel and on the stipules of some of the Leguminosæ. Flowers which offered such attraction would be most frequented, and from being oftener crossed would give rise to more numerous and more vigorous seeds. Their descendants would inherit these peculiarities in a still higher degree. Colour and perfume would now come to be of service as additional attractions, the deepening of the flower-tubes in order to reserve the nectar for special visitors would follow, while corresponding modifications in the proboscis and other organs of those insects most dependent on the flowers might be expected to take place. In this way Darwin conceived it possible that in process of time the innumerable and wonderful contrivances for effecting the cross-fertilization of flowers through insect agency might have been called into existence. More recently Henslow has endeavoured to account for such peculiarities in flowers as the colour of the petals, their markings, the secretion of nectar, irritability of certain parts, coronas, spurs, &c.; on the theory that they have been called forth as the result of a localized flow of nutriment induced through irritation caused by insects in visiting the flowers.

Neither of these explanations appears fully to meet the difficulty presented by fruits adapted to birds. In berries the softening of the fruit appears to have gone on simultaneously with the hardening of the seeds. In drupes the outer layer of the pericarp has grown soft while the inner layer has at the same time become indurated. It is by no means obvious how this differentiation of tissues could have originated. If we might hazard a conjecture, it would be that succulent fruits are related to those having an elastic pericarp which splits and forcibly ejects the seeds within. The latter we take to represent a more primitive type. Hygroscopic fruits which in drying contract and suddenly explode, scattering their seeds in all directions, are not uncommon. Hygroscopic agency is indeed very generally employed as a means of dispersion; we find it adopted in all classes of plants. The twisting of the pods of the broom and the lotus, the spreading of the plumes composing the thistledown, and many similar phenomena, result from slight differences of adjoining tissues which cause them to dry at different rates. A piece of unseasoned timber warps in the same way because the green sap-wood on the one side dries more rapidly than the heart-wood on the other. The turgescence of certain tissues producing tension and sudden rupture accounts for the power of the mortar-fungus to project its spores. By this means some fungi literally bespatter with their sticky spores the leaves and stems of surrounding plants. The squirting cucumber when ripe breaks away from its stalk, and, by the forcible contraction of its walls as well as by the pressure of fluid within, the seeds along with the watery contents are shot out as from a syringe.

Better known examples of elasticity are the fruits of the hairy cress and the balsam. If these ripe fruits be touched the valves or carpels suddenly curl up and the seeds are thrown out all around.

On the assumption that birds at first simply fed on seeds, and that certain fruits and seeds already showed a tendency to become differentiated into an external soft and an internal hard layer, possibly as a means of scattering the ripe seeds by hygroscopic action, it is not difficult to see how there would be initiated a course of variation and natural selection which, by accentuating the difference between the two layers, would ultimately secure the complete protection of the seeds, and at the same time provide an inducement in the shape of sweet pulp sufficiently attractive to insure the services of the feathered tribes.

THE LONDON BASIN.

By Edward A. Martin.

To those who live in the suburbs of London, geology has a special interest, as, by its assistance, one is enabled to solve questions as to the composition and sanitary qualities of the various soils in the metropolitan area. Enquiries are often being made by persons about to choose a house, as to which neighbourhood is a healthy one to live in, and where one can find a good gravel soil. It is to be feared, however, that with the comparatively small area of gravel in the suburbs of London, only a few can choose such sites, and many have to put up with a clay soil. In that case, a house on a hill, or on rising ground, is preferable to one in a valley, or on flat ground, whilst the chalk hills which almost completely surround London would be found to afford a far better site than any of the London formations. But in London, with the exception of a very small district in the south-east, the chalk does not appear at the surface at all, being regularly covered by one or more formations belonging to the Eocene age, of which representatives are occasionally found in the South of England, *e.g.*, at Newhaven, Seaford, Furze Hill, Brighton, and in Hampshire. The chalk, as it approaches London from the south, most aggravatingly

sinks beneath the surface at a line joining the towns of Epsom, Sutton, Croydon, Orpington, and Sevenoaks, and to such a depth that, at the spot where a shaft was sunk by the Southwark and Vauxhall Water Company at Streatham a year or two ago, the chalk was only arrived at after traversing 241 feet of tertiary beds of clay, gravel, and sand. When, however, we pass beyond the northernmost limits of London, we again find the chalk immediately beneath our feet, cropping out from beneath these tertiary beds, at a line joining the towns of Watford, Rickmansworth, Beaconsfield, Marlow, Maidenhead, on to Reading and Hungerford, and forming the long southern slopes of the Chiltern Hills.

Thus we see that the whole of London, and the beds on which it is built, are held in the hollow of a trough in the chalk, the hills forming a natural boundary both north and south.

The beds above the chalk may be classified as follows:*—

1.	Made Earth, Alluvium.	3. London Clay.
		4. Oldhaven (Pebble) Beds.
2.	Brick Earth, Gravel and Sand.	5. Woolwich & Reading Beds.
		6. Thanet Sands.

A detailed sketch of each of these is scarcely called for here; a few characteristics, however, and the places where they can be seen may be of interest.

The Thanet Sands (6) are one of the most well-marked divisions of the tertiary strata. They attain their greatest thickness on the north-east coast of Kent, being 90 feet thick in the Isle of Thanet, from which they take their name. As we approach London in a westerly direction the bed gradually thins out, so that when we reach the Bank of England it is only 40 feet thick, and at Ealing, to the west of London, it has but a thickness of eight feet. The materials of which the bed is composed have a special characteristic attaching to them, and one which serves to show, to some extent, the source from whence the sand was derived before being laid down by the sea which once covered them. Under a microscope the particles of sand are ascertained to be of a regular crystalline form, altogether unlike the rounded grains of sands of which, for instance, the Brighton sands are composed. Now in Belgium there is a wide extent of country, the surface of which is composed of primary crystalline rocks, containing a large proportion of quartz, which is exactly the same as sand and flint in its chemical composition. This fact, together with the fact stated above, that the sands are thickest in the east and thin out to the west, serves to show that the sea denuded the crystalline rocks and washed the quartz westward, laying it down where we now see it, but only transporting the material in diminishing quantities to the west, the beds altogether dying out beyond Richmond. There are some sand pits at Charlton, near Woolwich, where it has a thickness of some 50 feet. Large quantities are there quarried and shipped as ballast by vessels going down the Thames. The vertical cliff caused by these quarrying operations shows us the topmast layer of the chalk at its base, whilst between the two is a thin layer, perhaps six inches thick, of flints. This layer is no doubt owing to the soft chalk having been washed away, the heavier flints being left behind by the water which denuded the chalk.

At Charlton the beds known as the Woolwich series (5) are also well developed. Similarly they are to be seen in full force at Castle Cliff, Newhaven, and at Seaford. The most remarkable feature about these beds is that they include layer above layer of shells, packed tightly together in a matrix of clay. When a mass of this is dried it bears a close resemblance to the shell-marble found in the Weald, and known as Sussex or Petworth marble. Much of the shell-sand used largely in London for spreading over garden-paths is obtained from these beds.

The Oldhaven Beds, next to be mentioned, are recognisable at once in the neighbourhood of London. In a matrix of clayey sand are contained large quantities of rounded pebbles not larger than a hen's egg, and generally smaller. These pebbles are noticed in large numbers in Greenwich Park. Blackheath itself sometimes gives its name to the series, whilst those who have visited Croham Hurst, to the south of Croydon, cannot but have noticed the quantities of pebbles which are trodden under foot.

All these formations, however, sink into insignificance beside the deposit of London Clay (3), which, in some places, is as much as 90 feet thick. In the London Basin it covers a great part of the surface, and it is also to be found in full force in Hampshire, extending beyond the Solent into the Isle of Wight. Looking at a geological map of the country one cannot help being struck by a conviction that these deposits were once continuous with each other, and that the whole of the area between Hampshire and the Thames has since been so completely washed away that now not a trace is to be found in that part of the country. The character of the fossils which the London Clay affords, at once point it out to have been deposited in a sea perhaps quite as deep as that which in a previous age had laid down the chalk. Most of the low hills around London are formed of this clay, such as Shooter's Hill, the Sydenham Hills, Primrose Hill, &c. The London Clay is a very stiff clay, and is impervious to water, consequently the surface is always more or less damp, although the effects of this are greatly modified in a large part of South London, owing to a subsequent deposition of gravel above it.

After the London Clay had been gradually accumulating for many ages beneath the ocean, the bed of the sea came to be gradually upheaved, until at last it appeared as dry land, the greater part of what are now the British Isles probably partaking in the upheaval. Thus, during the Miocene age which followed, no deposits were laid down in the neighbourhood of London, although during the succeeding Pliocene age the coast-line again approached sufficiently near to allow of the deposition by the sea of those beds known on the Norfolk and Suffolk coasts as the Coralline and Red Crags. A gradual declension of climatal temperature had been going on since the tropical times of the London Clay, through the sub-tropical Miocene age, and the temperate Pliocene era, until now at the ushering in of Pleistocene times, the climate was not far short of arctic, and indeed the country, as it then was, soon became covered by an extensive ice-sheet, and glaciers came sliding down from the higher grounds bringing with them the rocks of their place of origin, and depositing their burdens as they melted in places far removed from the land of their birth.

In the North of England the result has been that thick banks of clay known as "boulder clay" and "till" have been formed, whilst imbedded in them have been found a few species of shells of a distinctly arctic character, and such as are not now found on the English coasts at all. In the north of London, on the hills of Hampstead and Highgate, a capping of this boulder clay is to be found, the valley of the Thames being a rough boundary corresponding to the southernmost edge of the sphere of glacial influence.

At last the glacial epoch passed away, and with the melting of the ice-sheet the land became raised above the level of the sea. The Thames, charged with an increased

* After Whitaker.

XUM

volume of water, cut its way through the beds which surrounded it, and, deriving large quantities of flints from the existing Eocene pebble beds, it proceeded to scatter them along its banks, and to deposit them in the then lower reaches of the river, thus giving rise to those wide tracts of "gravel and sand" (2) which cover so large an area in South London. These gravel deposits must not be confounded with certain gravel beaches and terraces which occur in the north of London and which owe their origin to the glacial conditions already referred to as also giving rise to the boulder clays.

In approaching London from the east, as soon as we get clear of a line drawn from Greenwich through Lewisham, and extended southward, we leave all the outcrops of the London tertiaries behind, with the exception of one, viz., the London Clay. This important formation, together with, in some parts, the river gravels, constitute almost the whole of South London between the imaginary line we have drawn, and a western boundary which we may fix as far west as Kingston and Wimbledon. The eastern part of Wimbledon Common is London Clay, and on the west the gravels are well developed. Tooting Common is situated on the clay, North Brixton and Clapham are mostly built upon gravel, although in the latter place the clay shows itself largely at Clapham Park. Sydenham, the Crystal Palace, and Forest Hill are built upon clay, but both north and south of the Palace there are two patches of gravel on the summit of the hills. Think of the time when the river was sufficiently broad to deposit this gravel, about six miles from the present river! Continuing eastward, we find a thick bed of gravel following the valley of the River Ravensbourne, identical in direction with the Lewisham Road, and reaching to the south of Bromley.

North of these places, and between them and the river, the surface consists of "gravel and sand," except of course in the immediate vicinity of the river. This would seem to show that the river, previous to laying down the gravel, destroyed a great part of the tertiaries, leaving only a part of the London Clay exposed, and then with the denuded fragments deposited the pebbles in the form of gravel.

Thus the work of destruction and denudation went on side by side with that of construction, the two actions to some extent counterbalancing one another.

It is a striking fact that the next formation—that of the Alluvium (1)—although found to so great an extent below London Bridge, is scarcely found at all above it, and this is, indeed, very likely to have been the cause of the choice of site on which the city was built. Over a large part of Bermondsey there appears this thick bed of river mud, whilst in the bed of the river, eastward from London Bridge, an important fault appears to have occurred, so that the strata on the north of the river have sunk down to a lower level than those on the south. The result of this fault was that the river spread itself over a wide tract of land on the north, and in prehistoric times deposited alluvium wherever it went. Even now the level is considerably lower than that on the south, and consists principally of wide stretches of marsh land.

THE FACE OF THE SKY FOR NOVEMBER.

By HERBERT SADLER, F.R.A.S.

THERE is no diminution in the increase of the number of solar spots and faculæ. The following are conveniently observable minima of some Algol-type variables (*cf.* "Face of the Sky" for October). U Cephei.—November 2nd, 0h. 11m. A.M.; November 6th, 11h. 50m. P.M.; November 11th, 11h. 30m. P.M.; November 16th, 11h. 10m. P.M.; November 21st, 10h. 50m. P.M.; November 26th, 10h. 29m. P.M. Algol.—November 2nd, 11h. 30m. P.M.; November 5th, 8h. 9m. P.M.; November 8th, 5h. 7m. P.M.; November 25th, 10h. 1m. P.M.; November 28th, 6h. 49m. P.M. λ Tauri.—November 2nd, midnight; November 6th, 10h. 53m. P.M.; November 10th, 9h. 45m. P.M.; November 14th, 8h. 37m. P.M.; November 18th, 7h. 29m. P.M.; November 22nd, 6h. 23m. P.M.; November 26th, 5h. 15m. P.M.

With the exception of Jupiter and Neptune, none of the planets are well situated for observation by the amateur in November. Mercury is practically invisible as, though he sets on the last day of the month at 4h. 40m. P.M., or 46 minutes after the Sun, his tremendous southern declination ($25\frac{3}{4}°$) will preclude observation. The same may be said of Venus, setting as she does on the 30th at 4h. 55m. P.M., or 1h. 1m. after the Sun, with a southern declination of 24° 19′. Mars does not rise on the last day of the month till 3h. 39m. A.M., and Saturn not till 1h. 6m. A.M.

Jupiter is still a magnificent object in the evening sky, setting on the 1st at 1h. 15m. A.M., with a southern declination of 9° 48′, and an apparent equatorial diameter of $44\frac{1}{2}''$. On the last day of the month he sets at 11h. 26m. P.M., with a southern declination of 9° 15′, and an apparent equatorial diameter of $40\frac{1}{4}''$. The phasis on the preceding limb of the planet is now very perceptible, amounting at the end of the month to $\frac{4}{10}$ of a second of arc. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above, and the Sun 8° below, the horizon. On the 1st, an eclipse reappearance of the first satellite at 7h. 37m. 53s. On the 2nd an occultation disappearance of the second satellite at 7h. 39m. P.M. On the 3rd an eclipse reappearance of the third satellite at 5h. 27m. 25s. P.M. On the 4th, a transit egress of the second satellite at 5h. 38m. P.M., and of its shadow at 8h. 2m. P.M. On the 6th, a transit ingress of the third satellite at 11h. 10m. P.M., and an occultation disappearance of the first satellite at 11h. 34m. P.M. On the 7th, a transit ingress of the first satellite at 8h. 42m. P.M., of its shadow at 9h. 57m. P.M., and a transit egress of the satellite at 11h. 1m. P.M. On the 8th, an occultation disappearance of the first satellite at 6h. 2m. P.M., and an eclipse reappearance of the satellite at 9h. 33m. 32s. P.M. A transit egress of the first satellite at 5h. 29m. P.M. on the 9th; a transit egress of its shadow at 6h. 44m. P.M.; a transit ingress of the shadow of the fourth satellite at 7h. 27m. P.M.; an occultation disappearance of the second satellite at 10h. 7m. P.M.; a transit egress of the shadow of the fourth satellite at 11h. 6m. P.M. On the 10th, an eclipse disappearance of the third satellite at 6h. 21m. 17s. P.M., and a reappearance at 9h. 28m. 55s. P.M. On the 11th, a transit ingress of the second satellite at 5h. 15m. P.M., a transit ingress of its shadow at 7h. 50m. P.M.; a transit egress of the satellite at 8h. 8m. P.M., and of its shadow at 10h. 40m. P.M. On the 14th, a transit ingress of the first satellite at 10h. 34m. P.M. On the 15th, an occultation disappearance of the first satellite at 7h. 55m. P.M. On the 16th, a transit ingress of the first satellite at 5h. 3m. P.M., of its shadow at 6h. 22m. P.M.; a transit egress of the satellite at 7h. 21m. P.M., and of its shadow at 8h. 40m. P.M. On the 17th, an eclipse reappearance of the first satellite at 5h. 58m. 3s. P.M.; an occultation reappearance of the first satellite at 6h. 23m. P.M.; an occultation reappearance of the third satellite at 8h. 21m. P.M.; an eclipse disappearance of the third satellite at 10h. 23m. 32s. On the 18th, a transit ingress of the second satellite at 7h. 47m. P.M., of its shadow at 10h. 28m. P.M.; and a transit egress of the satellite at 10h. 41m. P.M. On the 20th, an eclipse reappearance of the second satellite at 7h. 23m. 26s. P.M.

On the 21st, a ninth magnitude star will be situated a few seconds of arc north of the planet, actual conjunction with the centre taking place at about 5h. P.M. On the 22nd, a transit ingress of the first satellite at 6h. 56m. P.M., of its shadow at 8h. 18m. P.M.; a transit egress of the satellite at 9h. 15m. P.M., and of its shadow at 10h. 35m. P.M. On the 24th, an eclipse reappearance of the first satellite at 7h. 53m. 43s. P.M.; and an occultation disappearance of the third satellite at 8h. 48m. P.M. On the 25th, a transit egress of the shadow of the first satellite at 5h. 4m. P.M.; and a transit ingress of the second satellite at 10h. 22m. P.M. On the 26th, a transit egress of the shadow of the fourth satellite at 5h. 18m. P.M. On the 27th, an eclipse reappearance of the second satellite at 10h. 0m. 45s. P.M. On the 28th, a transit egress of the shadow of the third satellite at 7h. 40m. P.M. On the 29th, a transit egress of the shadow of the second satellite at 5h. 14m. P.M. On the 30th, a transit ingress of the first satellite at 8h. 52m. P.M., and of its shadow at 10h. 13m. P.M. Jupiter is stationary on the 3rd, and after that pursues a short direct path in Aquarius, but without approaching any naked eye star.

Neptune is admirably situated for observation, coming into opposition with the Sun on the last day of the month at a distance from the earth of about 2680½ millions of miles. He rises on the 1st at 5h. 53m. P.M., with a northern declination of 20° 6′ and an apparent diameter of 2·7″. On the 30th he rises at 3h. 51m. P.M., with a northern declination of 19° 59′. He describes a short retrograde path in Taurus, to the N.W. of ε Tauri. A map of the stars down to 10½ magnitude near his path will be found in the *English Mechanic* for October 16th, 1891.

November is a very favourable month for shooting stars. The most marked displays are the *Leonids* on November 13th and 14th, the radiant point being in R.A. 10h. 0m., northern declination 23°. The radiant point rises at about 10h. 15m. P.M. The *Andromedes* occur on the 27th, the radiant point being in R.A. 1h. 40m., northern declination 43°.

The Moon is new at 6h. 33m. P.M. on the 1st; enters her first quarter at 8h. 46m. A.M. on the 9th; is full at 0h. 16m. A.M. on the 16th; and enters her last quarter at 8h. 26m. A.M. on the 23rd. She is in perigee at 1·2h. A.M. on the 14th (distance from the earth, 225,015 miles), and in apogee at 8·8h. P.M. on the 25th (distance from the earth, 251,690 miles). The greatest eastern libration is at 3h. 6m. A.M. on the 7th, and the greatest western at 7h. 16m. P.M. on the 9th. There will be a very fine total eclipse of the Moon on the night of the 15th and early morning of the 16th. The first contact with the penumbra is at 9h. 37m. P.M. on the 15th; with the shadow (at 55° from the northernmost point of the Moon's limb towards the east, direct image) at 10h. 35m. P.M.; beginning of total phase, 11h. 37m. P.M. on the 15th; middle of the eclipse, 0h. 19m. A.M. on the 16th; end of total phase, 1h. 0m. A.M. on the 16th; last contact with the shadow (at 95° from the northernmost point towards the west) at 2h. 3m. A.M. on the 16th; last contact with the penumbra at 3h. 1m. A.M. on the 16th. The magnitude of the eclipse (Moon's diameter = 1), 1·386.

Chess Column.

By C. D. Locock, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

SOLUTION OF PROBLEM No. 4 (*by J. Oehgnist*) 1. Q to R8, K to Q3; 2. Kt to B7 ch. etc., anything else; 2. Kt to Q7 ch., etc. The above was a prize problem in a recent tournament of the Helsingfors Chess Club.

CORRECT SOLUTIONS from:—K, Alpha, H. S. Brandreth, M. B. (Jesmond), C. T. Blanshard, C. S., Giu. Pianissimo, J. G. Ellis, T. A. Earl, W. T. Hurley, W. E. B., R. W. Houghton, Betula, G. F., R. T. M., A. Rutherford, F. R., J. Taylor, R. W. Compton, and T.—(20 correct, 1 incorrect.)

T.—Your solution is counted correct, though it is barely legible. Could you not rectify this in future?

C. T. Blanshard.—Many thanks; but got your letter too late to make use of ticket.

G. F.—The Centre Counter Gambit is undoubtedly the best defence when receiving the odds of QKt.

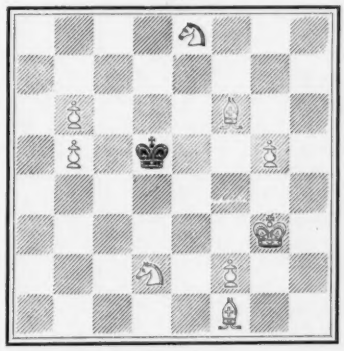
C. S.—The revised position is a great improvement, but there seems to be no mate after 1. . . B to Ksq. Should be glad to insert when sound.

J. Taylor.—No mistake was noticed. 2. Kt to B3 is equally good after 1 . . . P to Kt3.

PROBLEM (No. 5).

By D. R.

BLACK.



WHITE.

White to play, and mate in three moves.

The attention of competitors is called to the following amended rule:—"Should a problem admit of more than one key-move, *two* additional points will be awarded for each discovery of such key-move in the case of two-move problems, and *four* additional points in the case of other problems. The same number of marks will be deducted should any such claim prove incorrect."

LEADING SOLVERS' SCORES.

Alpha	22	R. T. M.	22
W. E. B.	22	A. Rutherford	22
W. T. Hurley	22	T.	22
K.	22	J. Taylor	22
Giu. Pianissimo	22	Betula	18
T. A. Earl	22	T. E. Kerrigan	14
F. R.	22	E. B.	14
R. W. Houghton	22	J. Landau	14
G. F.	22	J. G. Ellis	14
C. S.	22	White Knight	14
M. B. (Jesmond)	22	H. S. Brandreth	11
C. T. Blanshard	22		

Mr. T. E. Kerrigan has unfortunately been compelled to retire owing to illness.

XUM

CHESS INTELLIGENCE.

Another tournament is in progress at Simpson's Divan, 101, Strand. The players are the same as in the previous competition, with the exception that Mr. Rolland takes the place of Mr. Lee. Messrs. Tinsley and Loman have made the best start. The former did not sustain his reputation in the former tournament, which was won by Mr. Loman. The latter player has recently won the first prize in the National Tournament at Amsterdam.

Mr. Blackburne played 8 games blindfold at the City of London Club, on October 5th, winning 5, drawing 2, and losing 1. Playing simultaneously at the same club on October 9th, he won 16, drew 3, and lost 1.

For the "*Chess Player's Annual and Club Directory*, 1892," the authors, Mr. and Mrs. T. B. Rowland, 11, Victoria Terrace, Clontarf, Dublin, invite the following particulars of chess clubs:—Town, club name, year established, place of meeting, days, hours, number of members, annual subscription, laws, president, hon. secretary's name and address. Printed forms will be had on application.

Game played at the late Oxford meeting of the Counties' Chess Association.

[Hungarian Defence.]

WHITE (H. W. Trenchard).	BLACK (E. Thorold).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to K2
4. P to Q4	4. P × P
5. Kt × P (*a*)	5. Kt to K4 (?)
6. B to K2 (*b*)	6. P to Q3
7. P to KB4	7. Kt to Kt3
8. Castles	8. Kt to B3
9. QKt to B3	9. P to KR4 (?) (*c*)
10. P to KR3 (*d*)	10. P to B3
11. B to K3	11. Q to B2
12. Q to Ksq	12. B to Q2
13. Kt to B3 (*e*)	13. P to R5 (*f*)
14. Kt to Kt5	14. Kt to R4
15. B × Kt	15. R × B
16. Q to K2	16. R to R3 (*g*)
17. QR to Ksq (*h*)	17. Q to R4
18. Kt to B3 (*i*)	18. R to Rsq
19. P to B5 (?)	19. Kt to K4
20. Q to B2	20. Castles (QR) (*j*)
21. B × P	21. Kt × Ktch
22. P × Kt	22. K to B2
23. P to Kt4 (!)	23. Q to K4 (*k*)
24. Kt to K2	24. P to B4 (*l*)
25. P to KB4 (!)	25. Q × KP
26. Kt to B3	26. Q to B5 (*m*)
27. Q to Q2 (!)	27. B to KB3
28. Kt to Q5ch	28. K to B3
29. P to Kt5ch	29. Q × P (*x*)
30. R to Ktsq	30. B to Q5 ch (!)
31. K to R2	31. Q to R5 (*n*)
32. R to Kt6ch!	32. K × Kt
33. P to B4ch (*o*)	33. K to K5
34. Q to KKt2ch	34. K × P
35. Q to Kt5ch	35. K to K5
36. Q to Q5ch	36. K to Q6
37. Q to B3ch	37. B to K6 (*p*)
38. R to Qsq ch	38. Q × R
39. Q × Qch, and wins	

NOTES.

(*a*) P to B3 is also good. Black cannot take the Pawn on account of the reply Q to Q5.

(*b*) Too defensive. There is nothing to fear from 6. B to Kt3, P to QB4?; 7. Kt to B5, P to B5; 8. Kt to Q6ch, etc.

(*c*) Black has a bad game, but this unseasonable attempt at counter-attack does not improve it. He would do better to Castle and retire his Knights.

(*d*) Partly with a view to his next move, partly to prevent B to Kt5, which would free Black's game a little. Black has now practically nothing to do.

(*e*) To prevent Black's castling (QR). It seems a pity, however, to move the Knight yet. He might play QR to Qsq, and if Black Castle (QR), then P to QKt4.

(*f*) An ingenious reply. White gains nothing by 14. P to B5 ?, Kt to K4; 15. Kt × P, Kt × P, etc.

(*g*) Much better retire all the way. *Vide* move 18.

(*h*) Not very intelligible. He should play Q to B2 first, at any rate, and decide afterwards where he wants the Rook. Some players would be tempted by 17. Kt × KBP, K × Kt; 18. P to B5, Kt to K4; 19. B × R, P × B; 20. Q to R5ch; but Black's two Bishops might eventually prove too strong.

(*i*) There is no necessity to retire. He might amend his last move by R to Qsq. This and his next move were probably made under pressure of the time-limit.

(*j*) There is no point in this sacrifice. He might play Kt × Kt, followed by B to B3, or B to Qsq.

(*k*) If 23. . . . Q × KtP, 24. R to Ktsq; winning the Queen or Mating. Mr. Trenchard on his next move rejects B to Kt6ch, which would leave him with R and Kt against two Bishops (*vide* March No.), while Black might get some counter-attack, beginning with P to KKt3.

(*l*) Here R to Rsq is certainly better. If then 25. P to QB4 (threatening B to Q4), P to QB4.

(*m*) Q to Q5. Either now or next move would obviously lose a piece.

(*x*) After 29. . . . K × P, 30. R to Kt sq ch, K to R3; White mates in five moves.

(*n*) If Q to B5, White mates in three moves.

(*o*) Very pretty. If Q × P, mate follows on the move; if K × P, in three.

(*p*) Black's moves are all forced. If 37. . . . K to Q7. 38. R to Kt2 ch!

Mr. Trenchard's play from the 23rd move is a fine exhibition of vigour and accuracy.

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